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Optimizing daytime short sleep episodes to maximize performance in a stressful environment

Godfrey, Alison G.

Monterey California. Naval Postgraduate School

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

OPTIMIZING DAYTIME SHORT SLEEP EPISODES TO MAXIMIZE PERFORMANCE IN A STRESSFUL ENVIRONMENT

by

Alison G. Godfrey

September 2006

Thesis Advisor:	Nita Lewis Miller
Second Reader:	Lawrence G. Shattuck

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OPTIMIZING DAYTIME SHORT SLEEP EPISODES TO MAXIMIZE PERFORMANCE IN A STRESSFUL ENVIRONMENT

Alison G. Godfrey
Major, United States Army Reserve
B.A., Georgia Southern University, 1989

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 2006

Author: Alison G. Godfrey

Approved by: Nita Lewis Miller
Thesis Advisor

Lawrence G. Shattuck
Second Reader

James N. Eagle
Chairman, Department of Operations Research

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ABSTRACT

This study provides the baseline and initial assessment of the napping habits of the United States Military Academy Class of 2007. This portion of a four-year longitudinal study examines data collected on 62 Cadets over 32 days from 4 October 2004 to 4 November 2004 using actigraphy data and sleep logs. Data were stratified and cleaned in accordance with nap infrastructure, a term used to differentiate between naps of different duration and times of day based upon the phases and waves with which they tend to be associated. A total of 607 naps were reported for a total of 73.3 hours of sleep in addition to primary nocturnal sleep (PNS). Naps ranged from 15 minutes to six hours in duration and occurred most frequently on weekdays. This finding contrasts with research on other adolescent college students. Weekend naps were shorter in duration, on average, than weekday naps. This finding was also a departure from current nap research findings. Consistent with other research, most naps were between 30 minutes to one and one half hours in length. Frequency and duration of naps was greatest on Wednesdays. The primary type of nap taken was restorative as opposed to appetitive or prophylactic in nature. Afternoon naps were more prevalent than morning naps possibly reflecting Cadet class schedule rather than sleep need. Suggestions for additional research are proposed.

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DEFINITION OF TERMS

CATAPLEXY	A sudden dramatic decrease in muscle tone and loss of certain reflexes, usually precipitated by strong emotional expression or by the intention of making a sharp movement or by startle; a part of the tetrad of narcolepsy *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
CIRCADIAN RHYTHM	The regular recurrence, in cycles of about 24 hours, of biological processes or activities, such as sensitivity to drugs and stimuli, hormone secretion, sleeping, feeding, etc. This rhythm seems to be set by a 'biological clock' which seems to be set by recurring daylight and darkness. Medical Subject Headings (MeSH®) Thesaurus, (1999, 27 May 2005). Retrieved 17 December 2005, from http://www.nlm.nih.gov/mesh/meshhome.html
DISENTRAINED	Isolation from diurnal environmental and social queues such as variations in light, temperature, cultural habit and pressures *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html

EEG-(ELECTROENCEPHALOGRAM)	Popularly known as "brain waves," EEG is a recording of differences in electrical activity between two regions of the brain, ordinarily recorded by means of electrodes applied to the scalp *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
EMG-(ELECTROMYOGRAM)	A record of the electrical activity which emanates from active muscles. It may also be recorded from electrodes on the skin surface overlying a muscle. In humans, the EMG is typically recorded from under the chin, since muscles in this area show very dramatic changes associated with the sleep stages. *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
ENTRAIN	To synchronize with zeitgebers, i.e., indicators of time, they may be clocks, mealtimes, work periods, position of the sun, etc *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
ENTRAINED	To train with diurnal environmental and social queues where no attempt is made to isolate subjects from variations in light, temperature, cultural habit and pressures *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
EOG-(ELECTROOCULOGRAM)	A system which records eye movements. An electrode placed on the skin near the eye records the change in voltage as the eye rotates in its socket and the negatively charged retina interacts with the positively charged cornea. Medical Subject Headings (MeSH®) Thesaurus,. (1999, 27 May 2005). Retrieved 17 December 2005, from http://www.nlm.nih.gov/mesh/meshhome.html

EVENINGNESS	A diurnal type, which has been used in scientific literature since the 1930's. This sleep and activity pattern is also referred to as "Owl" and defines the tenancy to rise late and perform well in late morning, early afternoon or late evening tasks. Core body temperature cycle is one of the biological functions linked to morningness tendency. (Carskadon, et al., 1993)
MORNINGNESS	A diurnal type which has been used in scientific literature since the 1930's. This sleep and activity pattern is also referred to as "Lark" and defines the tenancy to rise early and perform well in early morning tasks. Core body temperature cycle is one of the biological functions linked to morningness tendency. (Carskadon, et al., 1993)
ONTOGENETIC	Refers to the complete developmental history of the individual organism *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
SLEEP CYCLE	The regular alternation between NREM and REM sleep that characterizes any relatively lengthy and undisturbed period of mammalian sleep (A NREM period plus the following REM period equals one sleep cycle *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005, from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
SUPRA CHIASMATIC NUCLEUS	A group of nerve cells located above the optic chiasm *Basics of Sleep Behavior*. (1997). Retrieved 05 August 2005 from http://www.sleephomepages.org/sleepsyllabus/fr-c.html
ULTRADIAN RHYTHMS	Biological rhythms that exhibit a period shorter than 24 hours (i.e., a frequency greater than once every 24 hours); hence the name, which is derived from the Latin words Ultra, "beyond," and dies, "day" (24 hours)" (Carskadon, et al., 1993), p. 639)

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My deepest appreciation goes to…

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My Mother, for her unconditional love; my Father who is my standard in the constant bombardment of situational ethics; my children, who waited patiently for life after thesis; my sisters, who prayed for me when work would have done me in; Professor Nita Miller, my thesis advisor, who sparked in me a real passion for Human Factors, made a space on her crowded and coveted advisor roster, and proved to me that it really is “all about sleep.”; Colonel Larry Shattuck, my second reader, who provided expertise, perspective and rapid response to my every question or concern; COL Saverio Manago, who probably fell on his sword for me at least once; LTC Alejandro Hernandez, who made the system work under what seemed to be impossible odds; Nancy Sharrock who did not abandon the effort, formatted and processed until it was really over; Wayne Heard, (MAJ, USA Ret), for his constant encouragement and faith; Lisa Puzon who fixed my every administrative catastrophe; Professor Samuel Buttrey, Professor Lyn Whitaker, Professor Mathew Carmichael, Mr. Jeff Rothal and the Interlibrary Loan staff; for their encouragement, expertise and technical assistance.

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EXECUTIVE SUMMARY

This study provides the baseline and initial assessment of the napping habits of the United States Military Academy Class of 2007. This portion of a four-year longitudinal study examines data collected on 62 Cadets over 32 days from 4 October 2004 to 4 November 2004 using actigraphy data and sleep logs. Data were stratified and cleaned in accordance with nap infrastructure, a term used to differentiate between naps of different duration and times of day based upon the phases and waves with which they tend to be associated. A total of 607 naps were reported for a total of 73.3 hours of sleep in addition to primary nocturnal sleep. Naps ranged from 15 minutes to six hours in duration and occurred most frequently on weekdays. This finding contrasts with results from research on other adolescent college students. Weekend naps were shorter in duration, on average, than weekday naps. This finding was also a departure from current nap research findings. Consistent with other research, most naps were between 30 minutes to one and one half hours in length. Frequency and duration of naps was greatest on Wednesdays than for any other day of the week. Based upon scientific literature and total nocturnal sleep, it was determined that the primary type of nap taken was restorative as opposed to appetitive or prophylactic in nature. Afternoon naps were overwhelmingly more prevalent than morning naps for both weekdays and weekends. This napping pattern may be more a function of Cadet class schedule than sleep need but does

provide critical information on the types and quality of sleep obtained by Cadets during this phase of their training. Suggestions for additional research are proposed.

I. INTRODUCTION

A. OVERVIEW

The mission of the United States Military Academy (USMA) at West Point is "To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country and prepared for a career of professional excellence and service to the Nation as an officer in the United States Army." (http://www.usma.edu/mission.asp, accessed 20 September 2006). The academic, physical and military training are challenging, the pressures are great and the expectations for each Cadet are high. The time to accomplish this extraordinary training is finite. Although not yet commissioned officers, the Cadets have to learn to face the types of challenges that are typical of those they will experience throughout the rest of their military careers. The military employs a strategy of “do more with less,” restructure, modularize and digitize. In the face of current strength challenges and a protracted Global War on Terrorism, missions given to the Army have increased in complexity while the resources provided have decreased. Despite changes in the variables of warfare and military life in general, some resources remain fixed. The primary resource and weapon of the Army is the soldier and there are only 24 hours in each day.

B. PROBLEM AND PURPOSE

Throughout history, napping, and even sleep, has been perceived by military leaders as a self-indulgent practice of undisciplined individuals. Yet the body is a system running on known fuels and requiring maintenance. The fuels

and maintenance for the human fighting system can be regulated to improve performance. To mismanage or ignore napping as a critical part of sleep, particularly for the human military system which frequently operates in stressful continuous work (CW), shiftwork (SW) and sustained operations (SUSOPS) environments, is to put the system at risk. This thesis provides a baseline description of the napping behavior of the USMA Cadet class of 2007 during the fall semester of 2004 and identifies its significance or value as determined through laboratory and field studies detailed in nap literature. Analysis will attempt to answer these questions:

- What are the current patterns of Cadet napping behavior?
- How much sleep is being gained by napping?
- What was the frequency of naps in this population over the 32-day period from 5 October to 4 November 2004?
- When did Cadets nap in:
    - a day?
    - a week?
    - over the period?
- What was the range of time Cadets nap?
- What was the average nap length?
- These findings will provide the basis for optimizing the length and duration of naps taken in conjunction with Primary Nocturnal Sleep (PNS), yielding the best possible performance for Cadets. Ultimately, these young men and women will become soldiers and leaders and the sleeping patterns they learn may have far-reaching consequences.

C. APPROACH

During the fall semester of 2004, two sets of data were collected. The first data set was sleep logs, reported by each of 62 participants, which captured both nocturnal and daytime sleep events. The second data set was collected using MiniMitter® Corporation Wrist Activity Monitors (Actiwatch-64™) worn by the same Cadets during 32 days in October and November. The actigraphy data collected were downloaded using Actiware® software version 3.4.1 software, which was originally designed to analyze nap data in conjunction with primary nocturnal sleep. Nap data from the sleep logs were manually input into Excel spreadsheets for nap analysis. Unfortunately, the Actiware® software Nap Analysis module was unable to analyze the data from the Actiware® 3.4.1 version download so naps could not be analyzed using the actigraphic records. Instead, data from the sleep logs served as the primary source for this study and were stratified, cleaned and analyzed using current sleep and napping research findings found in the scientific literature.

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II. LITERATURE REVIEW

A. SLEEP AND NAPPING ISSUES IN THE SCIENTIFIC LITERATURE

Understanding the complex processes of sleep and wakefulness, and their occurrence during the course of a 24-hour day presents challenges. This literature review will cover many of the issues important for understanding sleep, and in particular, napping behavior. Factors listed below may, in any given circumstance, be interrelated. Each of these factors affects the assessment of napping as well as the modeling and predictive analysis of the effects of napping practices on performance. The list is not intended to be all-encompassing, but represents issues important to consider in nap research.

- Biological Factors - Core Body Temperature, Suprachiasmatic Nuclei, Light, Heat, Body Position
- Environmental Pressures – Cultural Pressures, Zeitgebers
- Circadian Rhythms - Sleep Gates and Forbidden Zones
- Sleep Phases – Biphasic and Polyphasic
- Sleep Stages - Slow Wave Sleep (SWS) and Rapid Eye Movement (REM)
- Sleep Efficiency – Pre- and Post-Nap Effects, Sleep Inertia (S.I.) and Sleep Latency (SL)
- Duration Effects - < 20-min naps, 20-min to 1-hour naps, 1- to 2-hour naps, 2– to 3.5-hour naps, naps exceeding 3.5 hours.
- Personality Types – Morningness/Eveningness, Gender, Age
- Types of Nappers – Habitual Nappers, Non-Habitual Nappers and Non-Nappers

- Types of Naps - Prophylactic, Restorative and Appetitive Naps
- Sleep Schedules – Continuous Work, Shift-Work, Student Schedules
- Sleep Pressure – Sleep Deprivation, Sleep Debt

B. DEFINITION OF NAPS AND ADOLESCENT POPULATION

The normal adolescent population examined in this literature review consisted primarily of post-pubescent, males and females, in good general health, approximately eighteen to twenty-five years of age, with no apparent sleep disorders, and a consistent eight- to ten-hour nocturnal sleep schedule. The circadian rhythm group into which the Cadet population falls most closely mirrors that of the adolescent circadian rhythm group. As with all research, results of nap research must be interpreted in accordance with the definition of napping used and the conditions under which the study was conducted (Dinges and Broughton, 1989).

Most researchers agree that sleep is best described as a continuum of sleep and wakefulness and can be thought of as an undulating wave. Napping is then an integral part of that sleep and wakefulness wave even though naps account for less than 25% of total daily sleep time (Campbell and Zulley, 1989a). In the scientific literature, the term “nap” has been used variously to describe a brief morning recovery sleep after a sleepless night; a prematurely aborted nocturnal sleep period; mid-afternoon sleep periods augmenting the normal nocturnal sleep pattern; and even the involuntary sleep episodes of narcoleptics and those suffering from sleep apnea (Lavie, 1989). Lavie (1989) suggests that these sleep episodes are different in depth and sleep stage content and therefore, the term nap should

not be used interchangeably to describe each of these episodes. Current accepted research concludes that naps are not miniatures of nighttime sleep (Naitoh and Angus, 1989). The architecture of naps varies not only from PNS episode but also among naps in REM, Non-REM and SWS states. To recap some of the differences: the greater the sleep debt, the more efficient the nap; the longer the nap, the more likely REM and SWS are to occur; the more SWS, the greater the sleep inertia. Morning naps can be expected to contain more REM; afternoon and evening naps can be expected to contain more SWS.

How then do we characterize a nap vs. primary sleep, place parameters on it, predict its onset, determine the difference between one type of sleep and another or even differentiate between napping and major sleep? One possible way, according to Lavie (1989), is to categorize sleep episodes by location on the circadian time scale, proximity to the nocturnal sleep period and whether or not it supplements or replaces the nocturnal sleep period. The definition of naps for the USMA Cadet population takes on specific parameters identified later, but it is important to understand the structure of sleep in naps under the various circumstances in which they are likely to be found in our culture.

C. CIRCASEMIDIAN OR BIPHASIC NATURE OF SLEEP

To begin, each 24-hour cycle is divided into sleep and wake zones. According to Broughton, sleep/wake behavioral patterns are circasemidian or biphasic (Dinges and Broughton, 1998,). Assessments of sleep patterns conducted through research on sleep latency, ultradian

sleepability, napping during temporal isolation and napping among shiftworkers all strongly support this biphasic theory.

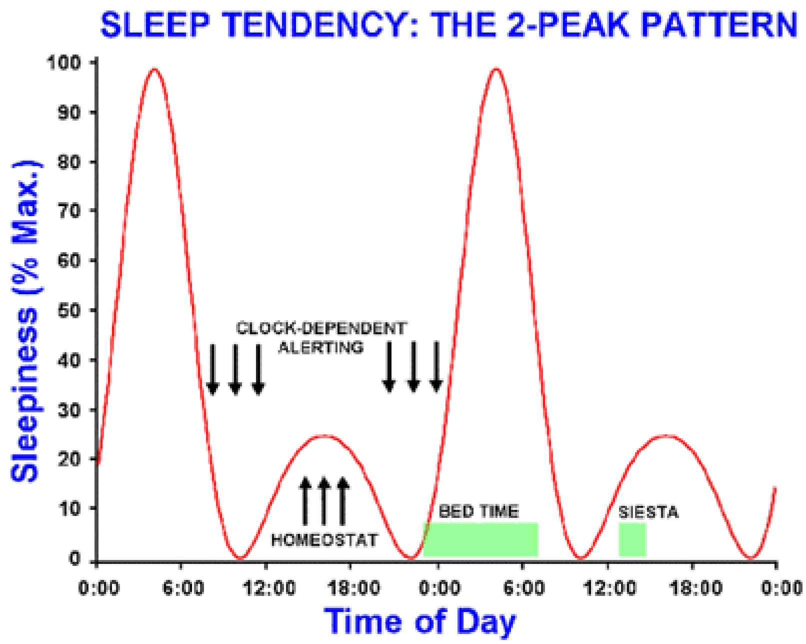

Figure 1. Illustration of bimodal and multiphasic nature of the circadian rhythm (From: http://sleepsmart.com/images/graph.gif, accessed 4 August 2005).

The two wake zones, depicted in Figure 1 as nadirs, are roughly uniform in length. However, the two sleep zones (nocturnal sleep, depicted as large amplitude peaks and afternoon nap, depicted as low amplitude peaks) are actually quite different.

In Broughton’s 1998 study, electrooculogram (EOG) and sub-mental EMG recordings of the sleep/wake behavior of 12 normal adolescent, habitual nappers representing both genders provides a visual image of biphasic napping behavior. In this study, habitual nappers were non-sleep deprived persons with a five-year habit of taking at least three naps per week of ten minutes or more in duration.

Broughton used four synchronizing queues for timing of the afternoon nap in normal habitual nappers, zeroing on: sleep onset, SWS onset, mid-sleep and wake-up. Of the four zeroing methods, zero (0°) at wake-up produced the tightest synchronization of data both numerically (with the smallest variance) and graphically (with the tightest distribution).

Measures of Daytime Sleep Distribution in Normal Subjects with Habitual Napping Patterns Using Alignment of Data at Different Locations of the Nychthemeron (Nocturnal Sleep Onset, Onset of Stage 3, Middle of the Nocturnal Sleep Period and Morning Wake-Up)

Variable	Alignment at: Sleep Onset	SWS Onset	Mid-Sleep	Wake-up
Peak Sleep Propensity	.37	.34	.33	.41
Variance (S.D.)	20.6	19.7	15.8	14.2
Distribution Kurtosis	-0.99	-0.94	0.26	0.86

Figure 2. Normal habitual napping patterns organized at four different start times to determine normal distributed alignment (From: Broughton, Krupa, Boucher, Rivers, and Mullington, 1998).

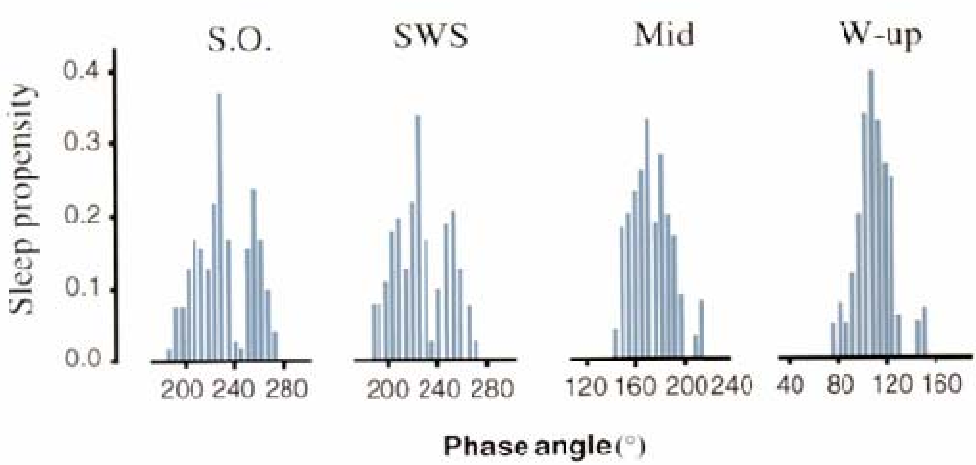

Figure 3. Frequency histograms of the sleep propensity of habitual nappers arranged with different start times (From: Broughton, et al., 1998).

With all data zeroed at wake-up, and habitual nappers combined, the distribution most closely corresponds to a normal distribution and a clear biphasic distribution of sleep-wake behavior emerged (Figure 3).

Sleep Propensity in Habitual Nappers

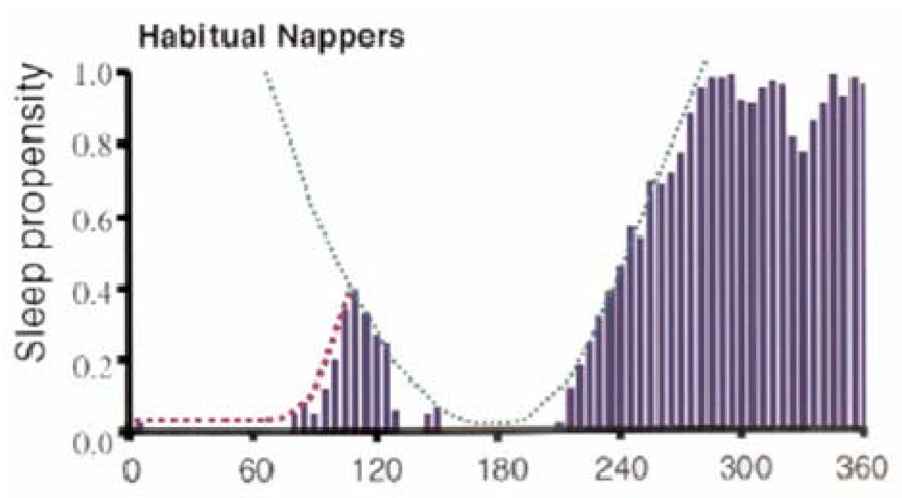

Figure 4. The sleep propensity of habitual nappers shows a biphasic tendency (From: Broughton, et al., 1998).

In the bar chart (Figure 4) of habitual napper data, wake up is at zero (0°) and bins represent five-minute periods. Increasing sleep propensity is represented by the heavy superimposed dotted line and the circadian arousal process is represented by the light dotted line. As the sleep propensity increases following wake-up, alertness decreases (Broughton, et al., 1998).

D. ULTRADIAN NATURE OF SLEEP/WAKE CYCLES

In addition to the biphasic nature of sleep/wake architecture, there exists a semi-sinusoidal alert/sleep pattern superimposed upon this circasemidian, bimodal distribution (Lavie and Scherson, 1981). This pattern traces the ebb and flow of sleepiness with its subsequent

decrement in performance even in healthy, non-sleep-deprived adolescents and is shadowed by a natural tendency to acquire additional sleep through short sleep episodes or naps.

Twenty-four Hour Circadian, Circasemidian and Ultradian Variations in the Probability of Wake-to-Sleep Transition

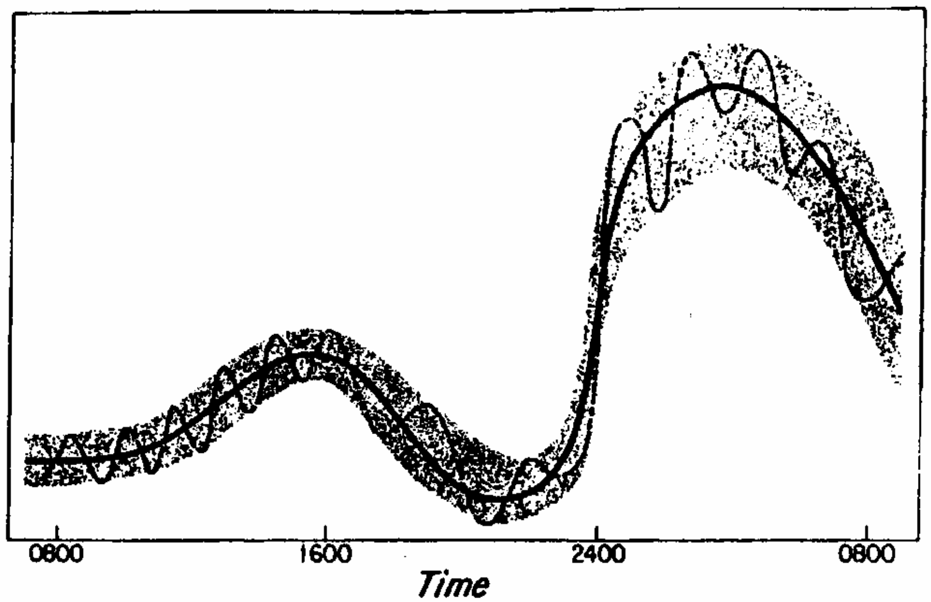

Figure 5. The 90- 120-minute ultradian sleep wake oscillations discovered by Lavie and Scherson (1981) superimposed upon the biphasic circadian sleep wake tendency. Here the Y axis measures sleep/wake tendency and micro-oscillations are graphs of brain activity measured through EEG (From: (Lavie and Scherson, 1981).

Lavie and Schershon (1981) discovered ultradian sleep/wake oscillations (as measured by changes in brain activity on EEG) in addition to the biphasic cycle, occurring with a frequency of approximately 14.4 cycles per day, and lasting roughly 100 minutes each. This ultradian cycle coincides with 90- to 120- minute periods of increasing and decreasing alertness (Kleitman, 1967). For the most part, studies of ultra short sleep/wake practices

have been too short in duration to account for adaptation to schedule changes. However, shiftwork studies have shown that schedule adjustments generally require approximately three to seven days to stabilize (Stampi, 1989).

E. SLEEP GATES

In addition to the ultradian nature of sleep, there exists a phenomenon, which has been called “sleep gates” (Lavie, 1986, 1989). Sleep gates are time periods approximately one and one-half to two hours apart at which time individuals are most able to fall asleep. Sleep gates are clustered in a primary and secondary time zone, which coincide with the biphasic nature of the circadian cycle. Sleep gates are found in both sleep-deprived and non-deprived individuals. The length of wakefulness changes the intensity but does not shift the time in which the two clusters appear. Intensity of sleepiness is most profound if the subject attempts to resist sleep onset. If the sleep gate is missed, it is more difficult for the participant to fall asleep (Lavie, 1986, 1989). "Forbidden Zones" are those zones of time separating nocturnal and diurnal sleep periods. In the forbidden zone, there are marked levels of arousal during which participants rarely initiate sleep (Lavie, 1986, 1989). Individuals who show an early nocturnal sleep gate demonstrated peaks in wakefulness, which occurred at 1200h and 2000h where those with late nocturnal sleep gates had peaks in wakefulness at 1500h and 2220h.

F. CORE BODY TEMPERATURE AS A PREDICTOR OF SLEEP/WAKE PROPENSITY

Some researchers project a sinusoidal distribution for core body temperature across a circadian scale and superimpose the distribution over a circadian sleep cycle.

Broughton (1998), through a meta-analysis of sleep studies, determined that core body temperature of entrained (where no attempt is made to isolate subjects from diurnal variations in light, temperature, cultural habit or social pressure) adolescent males is not sinusoidal but asymmetric and unevenly distributed. Below-average core body temperature occupies one-third of a 24-hour day and above average temperatures occupy the remaining two-thirds.

In keeping with Campbell and Zulley’s (1989) studies in entrained conditions of temporal isolation, Broughton found that napping occurs prior, but in close proximity to, maximum core body temperature. The lowest point in core body temperature during a 24-hour period is associated with the major sleep period. If this is true, attempts to model or make predictions about sleep/wake architecture using core body temperature as a predictor would produce inconsistent or disappointing results. In his meta-analysis of sleep/wake behavior in normal entrained, constant routine and temporal isolation environments, Broughton (1998) considered 221 separate mathematical models and concluded that a polynomial, least squares regression equation, which does not assume a cosine or sine wave shape, provided the best fit to predicting core body temperature in relation to circasemidian sleep/wake pattern for a 24-hour cycle. (Figure 6)

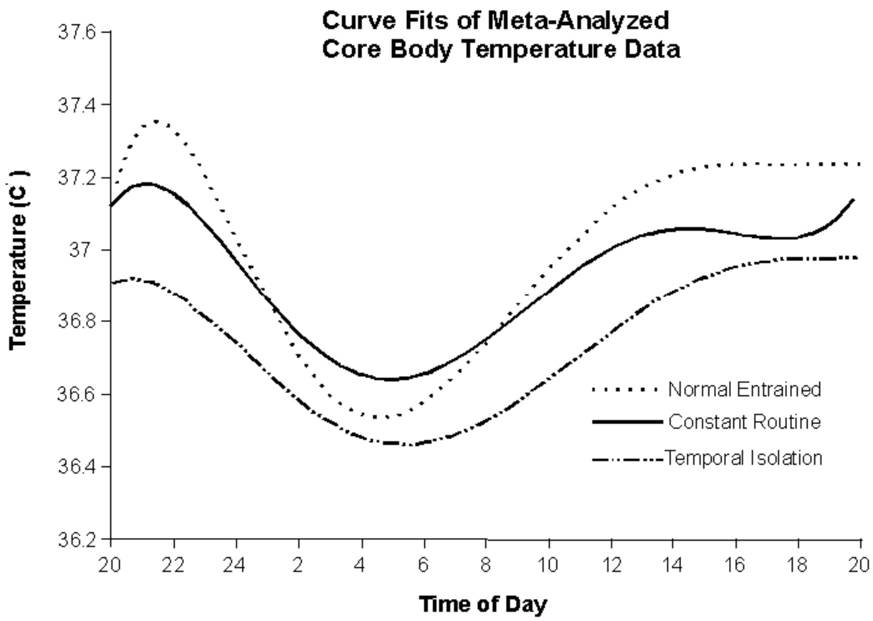

Figure 6. The polynomial, least squares regression curve as a predictor of core body temperature relationship to circasemidian sleep/wake patterns (From: Broughton, et al., 1998).

In Broughton’s study, he plotted sleep onset at 2300h, morning wake-up at 0700h with maximum daytime sleepiness appearing at 1500h (Figure 7) Borbély's Process-S, the sleep pressure caused by depletion of sleep reservoir (Borbély, 1982, 1987) increases exponentially during the waking hours of the day and decreases exponentially during sleep. “The circadian arousal process is plotted inversely to the shape of the circadian core body temperature curve in the entrained state” (Broughton, et al., 1998, p. 175). The nap zone appears at approximately 1500h as the maximum daytime sleepiness is overwhelmed by the circadian arousal process. “The combined processes generate the major sleep period, a post-sleep period of S.I., the morning wake maintenance zone (M-WMZ), the afternoon nap zone, the late afternoon/early evening wake maintenance zone (E-WMZ) and evening sleep onset" (Broughton, 1998, p. 175).

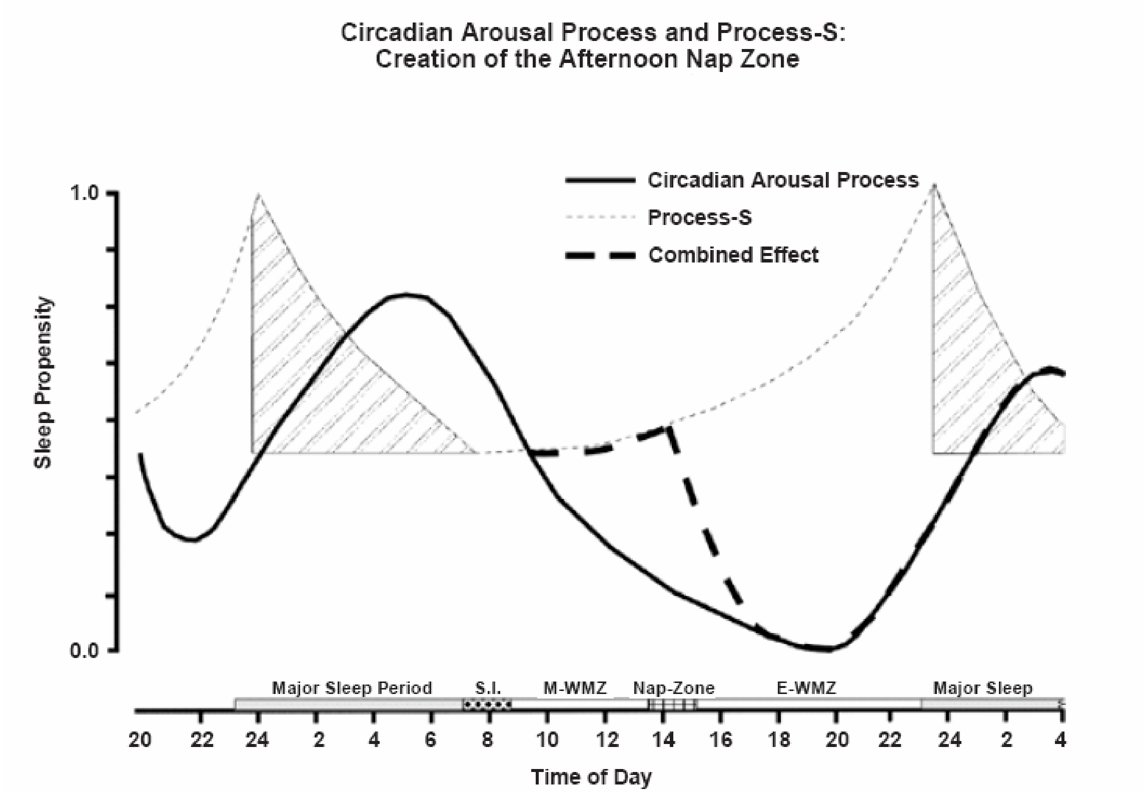

Figure 7. Broughton's Circadian Arousal Process and Process-S: Creation of the Afternoon Nap Zone (From: Broughton, et al., 1998).

G. SLEEP STAGES AND NAPPING

Campbell and Zulley charted the results of time-free studies and discovered that naps reoccurred in a non-random fashion (Campbell and Zulley, 1989a). Compilation of results indicate that sleep stages 1 and 2 are more likely and Slow Wave Sleep (SWS) is less likely during naps than during nocturnal sleep, hence supporting the common perception that naps are generally lighter than primary sleep (Campbell and Zulley, 1989b). For further explanation of the stages of sleep, see a previous thesis in this longitudinal study by Naval Postgraduate School (NPS) students, Kenney and Neverosky (2004).

Campbell's research suggests that there are two types of nap structures. Naps of the first type fall close to the mean (between 1400h and 1700h) in the nap time distribution curve resembling mini-nocturnal episodes and have nearly twice the incidence of SWS as the second type. The second type typically initiates at times outside the 1400h – 1700h range and is more fragile with fewer SWS incidents. Campbell and Zulley (1998b) state that morning naps have a tendency for sleep infrastructures similar to the final hours of nocturnal sleep. Assuming comparable nap durations, afternoon and evening naps have more SWS than do morning naps, with evening naps having the most SWS and the least REM sleep (Campbell and Zulley, 1989b). Afternoon naps have sleep infrastructures unlike both the beginning and end portions of nocturnal sleep (Campbell and Zulley, 1989b).

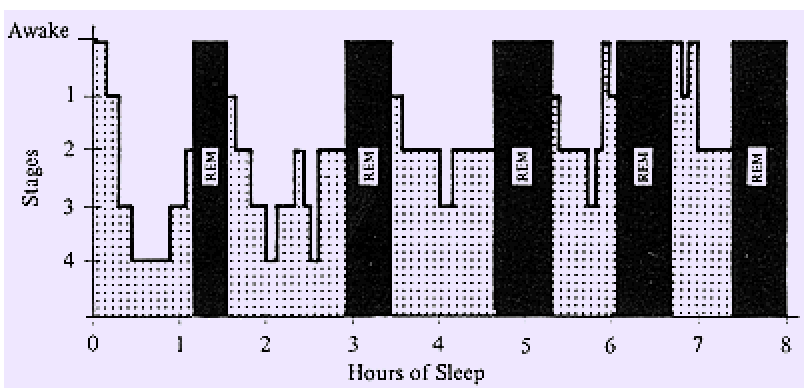

Figure 8. The typical quantity, placement of sleep stages in the nocturnal sleep zone as measured by EEG, EOG, and EMG in simultaneous recordings.(From: *Basics of Sleep Behavior, 1997).*

H. RAPID EYE MOVEMENT (REM) EFFECTS ON NAPPING

Once the initial sleep gate opens, it triggers the Non-REM timer. Once a critical amount of Non-REM sleep is reached, the first sleep REM episode begins. Subsequent REM

sleep occurs at 90-minute intervals regardless of the amount of Non-REM acquired. Awakening from REM sleep is associated with greater levels of alertness. Waking from other periods in the sleep cycle can generate a lack of alertness or S.I. persisting for an average of 30 minutes (Lavie, 1989). The onset of REM appears to be dependent on the amount of sleep time since the last REM onset. When REM sleep was present, it frequently occurred in close proximity to nap onset (Carskadon and Dement, 1975, 1977; Lubin, Hord, Tracy, and Johnson, 1976; Moses, Hord, Lubin, Johnson and Naitoh, 1975). However, multiple nap schedules appear to force the elimination of REM (Stampi, 1989). REM and sleep latency (SL) were found to be greater for naps taken between 0800h and 1200h than for naps taken in the afternoon or evening. REM sleep may occur during one-hour naps, but not in all subjects. REM sleep is very likely to occur in naps two hours or longer. If the nap is approximately 30 minutes in duration, REM sleep does not occur in healthy persons with no apparent sleep disorder. When REM sleep appears in naps taken between noon and midnight, it rarely occurs before 50 minutes after sleep onset. Subjective reports indicate most afternoon or evening naps (whether due to preference, sleep debt, social regulation or schedule difficulties) are approximately one hour in duration. It is not surprising then that REM is unlikely to be in found in large amounts for this napping period (Dinges, 1989; Maron, Rechtschaffen, and Wolpert, 1964).

I. SLOW WAVE SLEEP (SWS) AND NAPPING

The body guards against decrements in SWS, rebounding to bring SWS up to baseline levels (Stampi, 1989). However, the body will not attempt to regain lost quantities of REM

in the same manner as it does for SWS. REM and SWS occurring together was only cited in one study and was considered atypical. SWS was primarily found to occur in afternoon and evening naps and is associated with greater S.I. (Dinges and Broughton, 1989).

J. BIOLOGICAL SLEEP CUES

Current research indicates that the suprachiasmatic nucleus (SCN), a cluster of about 10,000 nerve cells, is the primary regulator of sleep behavior in mammals (Broughton, 1998). This super-concentration of nerve cells is responsible for stimulating approximately 10 million brain cells, which in turn influence trillions of other body cell cycles. The SCN transmits light cues via electrochemical signals from the eye to the visual portions of the brain. The brain uses these signals as time cues to adjust body temperature, hormone release and metabolic rate (Dement, 1999). These light queues which affect the body clock through the SCN, as well as other external environmental factors which tip the body off to the time of day, are known as zeitgebers. Zeitgebers frequently affect the levels of sleep acquired through napping during different times of day.

K. ADVERSE RESPONSES TO DAYTIME SLEEP (NAPS) AND SLEEP INERTIA

Sleep inertia and social ostracization are only two adverse reactions to daytime napping. Prolonged sleep periods, in excess of two hours, can cause a condition referred to as transient sleep inertia, characterized by reduced alertness, grogginess or inability to function upon awakening and lasting approximately 20 – 30 minutes. Disorientation and decrements in cognitive performance can be more severe if sleep is comprised of non-REM stages,

especially SWS, and such sleep occurs in relatively close temporal proximity to sleep termination as it can in afternoon and early evening napping (Dinges, Orne, Evans, and Orne, 1981; Orne, and Orne, 1975; Stampi, 1989).

The second adverse response to daytime napping is negative social response, which although not dangerous, can have serious ramifications within an uneducated population. Further longitudinal studies are needed to determine if biphasic or polyphasic sleep/wake patterns make a positive contribution to health, mood or performance.

L. CULTURAL DIFFERENCES AND NAPPING

It should be understood that napping has generally been excluded from sleep research. Napping, or sleep apart from the daily nocturnal phase, has typically been considered noise in a sleep data set and therefore excluded from data analysis. "The elimination of naps in the isolation studies has lead to theoretical models of sleep/wake regulation that ignored napping as an inherent component of the sleep/wake cycle" (Lavie, 1989, p. 100).

It is commonly accepted that most children nap. Still, what is more important to this study, is that napping is also prevalent in other populations such as college students, shift workers, persons engaged in prolonged activity and in locations across the world where the "siesta" is culturally accepted. However, the populace of most modern societies, the United States in particular, is socially oriented and defies the natural biphasic biological circadian rhythm, tending instead toward a monophasic sleep pattern. Phase shifts, shiftwork and continuous work schedule demands impose alterations or disentrainment to this basic pattern. Subjects in temporal

isolation have been known to nap even when the situation is prohibitive (Dinges and Broughton, 1989). Despite obvious geographic and cultural clustering, Broughton and Webb suggest that the midday dip in arousal may be endogenously, rather than culturally, motivated (Campbell and Zulley, 1989a; Lavie, 1989).

The USMA Cadet population can be categorized in multiple ways such as college student and persons engaged in prolonged activity. They will continue to be members of several categories throughout their military careers. After graduation as military officers, they will frequently conduct continuous and/or sustained operations. The military profession demands that officers continue to be students in a highly competitive and time-constrained environment. Over the course of their careers, they will continue to be involved in prolonged activity requiring physical, mental and emotional exertion. The profession of arms has historically not valued the "siesta" and has abused sleep in general as a proof of mental and physical toughness in an unwritten rite of passage.

M. INDIVIDUAL DIFFERENCES

Lavie's research revealed two distinct groups of individuals: sleepy and alert (Lavie, 1989). Sleepy subjects could fall asleep on cue and could not resist sleep when directed not to sleep. Alert individuals could not fall asleep on command and could resist sleep easily (Lavie, 1989). Campbell and Zulley (1989a) also concluded that there are long and short sleepers, other individuals who display a propensity to nap while still others display a propensity not to nap. In a two-week time-free experiment, where subjects were encouraged to eat and nap

at will, some subjects did not nap at all. In other experiments where subjects were prohibited from napping, more than fifty percent of the individuals were unable to comply (Campbell and Zulley, 1989a). Broughton (1998) shows that although sleepiness/alertness does vary in timing and intensity between individuals, the "afternoon nap zone" is not only predictable but also intense in all of them (Broughton, 1998).

Curtis and Fogel's study revealed a correlation between the ability to fall asleep given an irregular schedule of short nap periods and personality characteristics (Curtis and Fogel, 1972). An "increased ability to nap at irregular times correlated with higher scores on the California Psychological Inventory scales of Intellectual Efficiency, Sense of Well-Being, Dominance, Self-Acceptance, Sociability, Achievement via Conformance, and Psychological Mindedness and low scores on the Femininity Scale" (Stampi, 1989, p. 152).

N. SLEEP DEPRIVATION AND NAPPING

The need for afternoon sleep in humans increases in accordance with approximately 16 hours of prior wakefulness, corresponding to the time naps typically occur. Insufficient nocturnal and diurnal sleep increases sleep tendency throughout the entire day. Lavie (1989) documented ultradian oscillations of increased sleepability and alertness (each 20 to 90 minutes in duration) which are superimposed on the existing mid-afternoon increase in sleep propensity. Oscillations tend to increase in amplitude with increased prior sleep deprivation (Dinges and Broughton, 1989).

O. ADOLESCENT SLEEP REQUIREMENTS

Sleep quantity requirement remains constant at an average of 9.2 hours beginning at puberty and continuing throughout the adolescent years. In addition, adolescents show a delay of sleep onset and awakening (Figure 9). Adolescents show even later sleep patterns on weekends than on weekdays. In lab results, adolescent subjects would sleep in excess of nine hours per night if not forced to wake by the staff (Carskadon, 2002). Attempts to catch up on sleep over weekends by sleeping in late only reinforce the circadian shift (Dement, 1999).

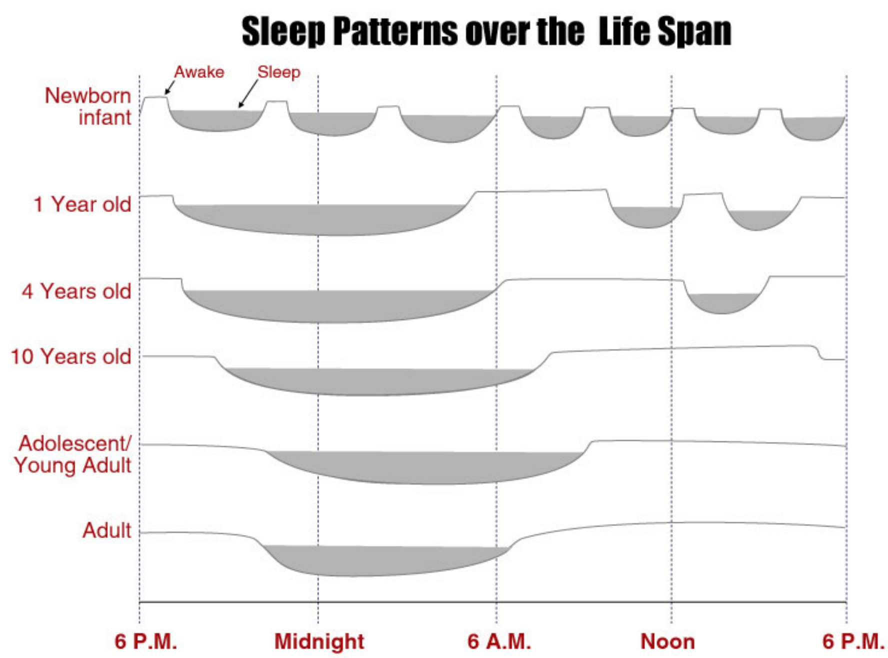

Figure 9. The multiphasic to biphasic transition, the multimodal to bimodal to unimodal shift, and the delay of sleep onset in a nocturnal sleep propensity from infancy to adulthood (From: N. Miller, L. Shattuck, lecture, March 2003).

P. SLEEP DEPRIVATION AND PERFORMANCE

Total sleep deprivation (TSD) can decrement performance, vigilance and mood (Johnson and Naitoh, 1974;

Naitoh, 1969). Sleep deprivation studies indicate sleep propensity increases with sleep debt and sleep deprivation is manifested in negative mood, decreased cognitive performance, and motor function. Attention, working memory, and divergent higher cognitive functions have been shown to be particularly vulnerable to sleep loss (Durmer and Dinges, 2005).

Some task performance can be measurably decremented with as little as 24 hours of TSD. In studies of performance during SUSOPS, subjects demonstrated profound decrements for tasks, intense sleepiness, negative mood, and were judged to be militarily ineffective after as little as three days of TSD (Haslam, 1982; Stampi, 1989). Sleep deprivation increases the probability that students will have automobile accidents, use drugs, be violent or aggressive or develop sleep disorders. Further, sleep deprivation affects adolescents more dramatically than any other age group (Dement, 1999). In one Minnesota school, a shift in start time from 0720h to 0830h was marked by “measurably higher” standardized test scores for 11th- and 12th-graders in the first year after the change (Dement, 1999). Alertness increased and behavioral problems went down. According to Johnson, Naitoh and Moses (1977), most literature substantiates that performance can be maintained at 60-70% with partial sleep deprivation which reduces the normal eight hours per 24-hour cycle sleep amount to approximately 4.5 to 5.5 hours.

Q. CONTINUOUS SLEEP VS. NAPS - THE QUALITATIVE VALUE OF SLEEP

When considering sleep efficiency (the ratio of time in bed to time asleep) in the tendency to nap, we know that nocturnal sleep efficiency roughly averages between 80% and

90%. Nap sleep, regardless of the time of day, rarely reaches beyond 80% efficiency. However, a one-hour afternoon or evening nap ranges between 55% and 70% effective (Daiss, Bertelson, and Benjamin, 1986; Dinges, 1989; Dinges, Orne, Evans, and Orne, 1981, Gillberg, 1984). Two-hour naps yield an efficiency somewhere between 65% and 80% (Dinges, 1986, 1989; Feinberg, March, Floyd, Jimison, Bossom-Demitrack, and Katz, 1985).

Under certain circumstances, a sleep plan, which includes napping, may be preferable to that of a single, contiguous nocturnal sleep episode of equal total sleep time (TST). A study by Hartley (1974) of reduced sleep time, continuous sleep and napping, divided participants into three groups: control, with unrestricted sleep, restricted sleep with naps and restricted but contiguous sleep with no naps but the same total sleep and as the nap group. The unrestricted sleep (control group) showed the best decision criteria selection. The reduced sleep with napping group scored lower than the unrestricted sleep group but scored significantly higher than the non-nap group (Hartley, 1974). Napping, then, was found to provide benefits to decision-making skills compared to continuous sleep. Stampi identifies three major rhythms to consider when determining the value of sleep of any duration: “(a) the sleep-propensity cycle (i.e., when transition from wakefulness is facilitated); (b) the sleep-efficiency cycle (i.e., when the same amount of sleep provides higher recuperative value) - note that the sleep-propensity and sleep-efficiency cycles are not necessarily synchronous; and (c) the sleep-inertial cycle” (Stampi, 1989, p. 165).

R. EFFECTS OF NAPPING ON HABITUAL NAPPERS AND NON-HABITUAL NAPPERS

1. Effects of Napping on Non-Habitual Nappers

Hayashi’s 2003 study of habitual and non-habitual nappers observed healthy, adolescent male and female non-habitual nappers under nap and no-nap conditions. Subjects were allowed to continue their regular sleep and wake routine but were asked to take short naps at noon every day for five days. Measures of sleepiness, mood, sleep latency and visual detection tasks provided both subjective and objective measures of fatigue and alertness. A similar procedure was followed using the same subjects for two weeks without naps. Participants followed the same procedure but were not given the option to nap. Analysis of Variance (ANOVA) showed that during the nap week there was a significant decrease in waking time after sleep onset. Visual detection reaction time only improved after the third day for nap week. Unfortunately, the study was only two weeks in duration limiting the inferences about the long-term effects of routinely scheduled short naps (Hayashi, Hirokazu, and Tadao, 2003).

2. Regular Nap Schedule and Decreased Sleepiness as a Function of Time

Hayashi (Hayashi, et al., 2003) examined eight university students using activity logs and actigraph monitors. During one week of the experiments, subjects were asked to rest but not sleep in a semi-reclining chair between 1230h and 1300h (1 hr). During the second week, they were asked to nap in a climate-controlled, dark, soundproof room during the same time period. Immediately before and after the rest or nap, subjective sleepiness and fatigue measures were taken. Students returned that same

day to perform modified visual detection tasks. For the nap week, afternoon fatigue and sleepiness decreased dramatically as a function of time. Figure 10 clearly illustrates that the nap group reported significantly less afternoon sleepiness than did the non-nap (rest only) group even though immediate post-nap results showed higher fatigue (Hayashi, et al., 2003).

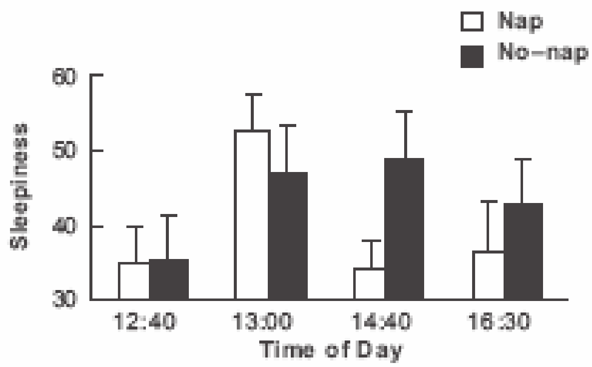

Figure 10. Mean sleepiness scores across five consecutive days (±SEs) immediately before (1240h) and after (1300h) napping or resting, and at mid-afternoon (1440h and 1630h)(From: Hayashi, et al., 2003).

An additional benefit was noticed as the protocol was followed over the five-day period (Figure 11). By day three, the nap group had increasingly lower sleepiness levels particularly toward the later afternoon testing (Figure 11). The nap group pre-nap fatigue was also significantly lower over the five-day period than the no-nap group (Hayashi, et al., 2003).

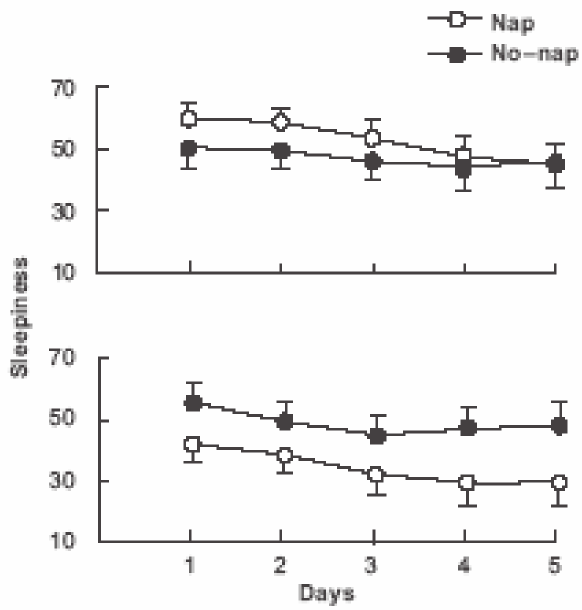

Figure 11. Sleepiness measured across the five consecutive day protocol (±SEs) immediately after napping or resting 1300h(top) and at 1440h (bottom) (From: Hayashi, et al., 2003).

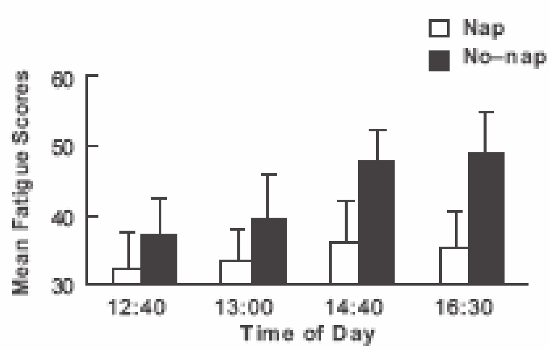

Figure 12. Mean fatigue scores among five consecutive days (±SEs) immediately before (1240h) and after (1300h) napping or resting, and at mid-afternoon (1440h and 1630h) (From: Hayashi, et al., 2003).

S. THE EFFECT OF NAPS ON NOCTURNAL SLEEP

Studies show napping does not harm or cause a significant shift in the nocturnal sleep gate as some might suppose (Dinges, 1989). Lavie's laboratory tests showed that the nocturnal sleep gate remained stable when sleep-

deprived subjects were permitted two-hour recuperative naps. On one trial, a two-hour nap was permitted starting at 1500h and ending at 1700h. On the second trial, a two-hour nap was permitted from 1900h to 2100h. In the second trial, there was greater post-nap sleepiness yet the time of the nocturnal sleep gate did not change. For both of Lavie’s experiments, the mean times of the nocturnal sleep gates were 2340h and 2400h respectively (Lavie, 1989). Although research is scant, current knowledge indicates that humans are very flexible and adaptable to frequent napping in a continuous work environment. Current findings indicate that in a continuous work environment, some naps are more effective than others.

Short naps have also shown higher restorative effect on performance than the same amount of continuous sleep (Stampi, 1989). Subjects in Hartley's study who were permitted three 80-minute-naps in a 24-hour period did not perform as well as control subjects who were permitted eight hours of continuous nocturnal sleep (Hartley, 1974). Lubin, et al. (1976) determined that forced bed rest is not a substitute for even short sleep episodes.

T. WHEN AND HOW OFTEN NAPS OCCUR

Currently, there are no systematic data which place clear parameters on a common time, place, environment, personality type, disposition or optimal schedule for napping (Dinges and Broughton, 1989). Daytime or secondary sleep zone, sleep gates, sleep pressure, schedule, cultural and environmental factors all play a significant role in determining when naps occur. However, some researchers suggest that time-free or disentrainment environments are a good place to gain insight into the unconstrained tendency

to nap. In early studies conducted under "time-free" conditions, subjects were prohibited from napping due to the initial belief that sleep in adult humans was monophasic and naps were variance, noise or distortions of clean data. Therefore, experimental demands replaced environmental and social demands, obscuring true sleep/wake patterns.

Universal to all definitions of napping within different experimental designs is that napping tends to cluster around times of maximum core body temperature. Maximum body temperature occurs approximately halfway between major sleep episodes (Campbell and Zulley, 1989b; Stampi, 1989). Naps typically occur 60% of the way between the cessation of one nocturnal sleep episode and the onset of the next (Campbell and Zulley, 1989b). In studies where subjects were confined to bed with no optional activities, mid-morning naps (between 0800h and 1100h) tend to occur more often than at any other three-hour time period. In disentrainment scenarios, naps occur an average of 2.2 times per 24-hour period (Campbell and Zulley, 1989b). In a study of varying periods of wakefulness over a 54-hour period, Dinges, et al. found that whether a two-hour nap was placed at the circadian peak or trough, a two-hour nap placed 12-hours apart from each other had little to no effect on performance demands as measured by Reaction Time (RT) and Stanford Sleepiness Scale (SSS), regardless of the degree of sleep debt (Dinges, Orne, Whitehouse, and Orne, 1987).

U. ADOLESCENT SLEEP TENDENCIES AND PRACTICE

To determine when college-age students have a propensity to nap, it is helpful to examine college-age

napping practices. In a study of college students (58 regular nappers, 14 regular non-nappers), and over 3,000 sleep onsets recorded on sleep logs, Dinges, et al. determined that two major sleep periods emerged. The first and primary period was the nocturnal zone (2300h to 0400h) comprising 85% of the sleep onsets and the second was the nap zone (1400h to 1800h) between which 15% of sleep onset occurs (Dinges, Orne, Orne and Evans, 1980).

V. DEPTH, QUALITY AND VALUE OF A NAP

While some researchers maintain that any napping is effective for maintaining and improving performance and mood in sleep deprived individuals, Naitoh (1983) determined that not all naps were equal. He stated that nap effect on performance could be predicted based on three variables: duration of prior wakefulness, time of day and nap duration. The more sleep deprived an individual is, the more sensitive he or she is to future sleep loss, regardless of restorative napping (Stampi, 1989).

W. DURATION OF A NAP

In studies of college students, Dement found that the mean nap length was .67 to 1.5 hours in survey data and .58 to 1.6 hours for daily log studies with an overall mean of 1.21 hours. Across studies, nap durations of less than 15 minutes or greater than two hours were uncommon (Dinges, 1989).

As opposed to TSD, which is found in many CW scenarios, sleep of any short duration has proven to be disproportionately effective over no sleep at maintaining performance (Lubin, et al., 1976; Opstad, Ekanger, Nummestad, and Raabe, 1978). Polyphasic sleep/wake cycles have been attempted with as short a cycle as five-minute-

sleep/15-minute-wake (Lavie, et al., 1981). Bonnet’s experiments lead him to conclude that ten minutes is the minimum nap duration to achieve marginal restoration in a CW environment (Bonnet, 1986).

X. SUSTAINED OPERATIONS (SUSOPS), CONTINUOUS WORK (CW) AND NAPPING TECHNIQUES

“The best examples of SUSOPs are undoubtedly those experienced by military and defense personnel during combat or an emergency” (Stampi, 1989, p.140). SUSOPS involves performance of essential and often critical services, which demand acute attention to sometimes monotonous and sometimes high-activity tasks. CW scenarios place a demand for activity or performance which may be prolonged or at very short or unpredictable intervals, preventing sleeping in the habitual monophasic six- to eight- hour nocturnal manner. The highly specific or skilled nature of the task precludes sharing the workload in shiftwork schedules resulting in accumulating sleep debt (Stampi, 1989). Naitoh and colleagues, as reported by Stampi (1989, p. 141) concluded that "the upper limit of human performance for working intensively and continuously… [is] two to three days when tasks are both physical and mental."

As little as one night of TSD has been shown to decrease performance levels for some tasks. Glenville, et al. found that vigilance tasks were most profoundly affected by one night of TSD but choice and simple reaction time tasks were also affected (Dinges, et al., 1987; Glenville, Broughton, Wing, and Wilkinson, 1978). By the fourth day of a study of performance during a sustained military operation with no sleep, all of more than 20 members of a British parachute regiment had withdrawn from the exercise (Haslam, 1982; Stampi, 1989). The group showed

profound decrements on performance for most tasks, intense sleepiness, negative mood, and by the third day without sleep, they were judged by observers to be militarily ineffective.

Researchers acknowledge that experimental environments cannot adequately capture the magnitude, diversity or interaction in sleep-restricted operational CW and SUSOPS scenarios. Bennet captured SUSOPS, CW and short/ultra-short sleep schedules in his field study of the 1972 single-handed trans-Atlantic yacht race (Bennet, 1973). The study included vigilance, endurance, skilled and mundane tasks requirements, high motivation, environmental factors and more. Shiftwork schedules were not possible for these one-man crews. Each yachtsman sought his or her most restorative sleep with the least S.I. The mean sleep episode across competitors was two hours (SD 1.7 hrs). Competitors with the best race time results practiced sleep episodes lasting from 20 minutes to one hour. Yachtsman who practiced sleep times of two hours tended toward rapid decline in performance, an understandable result as the horizon must be monitored not less than every 20 minutes under calm conditions.

The military, a key provider of critical services, is frequently required to conduct SUSOPS or CW. Therefore, it is important to address the measures that can be used to offset the negative repercussions and inevitable sleep deprivation of CW and SUSOPS schedules. Sleep storage, prophylactic sleep (a nap taken to ward off fatigue associated with future anticipated work schedule),

recovery, restorative and ultra-short sleep are all techniques which researchers have weighed to counterbalance the cumulative effects of CW and SUSOPS.

Y. SLEEP STORAGE AND PROPHYLACTIC NAPPING

Research has not indicated that sleep can be stored, or “banked” through extending the nocturnal sleep episode prior to known episodes of TSD. In fact, eight to ten hours is the limit of voluntary sleep extension for non-sleep deprived individuals and 20 hours is the apparent limit for severely sleep-deprived subjects. Rare cases of individual ability to store sleep have been documented but storage is not a universal capability according to current research. Herscovich, et al. and Taub, et al. as reported by Stampi (1989) found that "Extending sleep beyond the habitual amount may produce unpleasant physical and mental consequences for both non-sleep-deprived and partially sleep-deprived subjects as well as performance decrements similar to those experienced with total sleep loss” (Herscovitch and Broughton, 1981; Stampi, 1989 p. 141; Taub and Berger, 1973).

In a study on the effects of prophylactic vs. recovery naps on mood and performance given fifty-four-hour SUSOPS scenarios, researchers found that prophylactic naps were more beneficial on performance restoration than recovery naps even though restoration naps were longer in duration and deeper (Dinges, et. al., 1987). Prophylactic naps early in the experimental protocol demonstrated greater enhancements of performance for a more prolonged period of time than did prophylactic naps taken later despite the fact that the early naps were shorter and less deep than later naps (Dinges, 1986).

Z. RECOVERY OF SLEEP LOSS AND RESTORATIVE NAPPING

Restorative napping is the attempt to recover sleep. It is indisputable that sleep is the only cure for sleep loss. There is research available to support both sides of the claim that we nap to make up for lost nighttime sleep. Broughton, in a 1994 ambulatory study, determined that amounts of day and nighttime sleep were not closely correlated. This finding was later corroborated in a laboratory study of adolescent males and females (Harsh, 1998). However, in a 1998 ambulatory study of habitual nappers and narcoleptics, Broughton found that habitual nappers had a decreased need for nighttime sleep (Broughton, et al., 1998). In Haslam's study of military performance of soldiers in sustained operations, he found that 48 to 72 hours of TSD renders soldiers militarily ineffective but a small amount of recovery sleep relative to the amount of sleep lost yielded beneficial effects (Haslam, 1982). Lavie (1989) found that naps placed at the secondary gate for sleep (the nap zone) had higher sleep efficiency indices and more stage 3 and 4 sleep, and were more effective at reducing immediate post-nap sleepiness.

AA. ULTRASHORT SLEEP SCHEDULE

In CW or SUSOPS scenarios, the need to sleep and recuperate may prompt individuals to schedule multiple and repeated naps. "Ultrashort sleep schedules are characterized by multiple alternations of sleep and wakefulness, distributed throughout a 24-hour period; each alternation is generally shorter than three hours" (Stampi, 1989, p. 143). In Carskadon and Dement's 90-minute day study, ultrashort sleep schedules did not yield improvements to drowsiness until around the third or fourth

day, after which time, drowsiness levels achieved almost baseline levels (Carskadon and Dement, 1975, 1977; Lubin, et al., 1976; Moses, et al., 1975).

AB. SLEEP, NAPPING AND STIMULANTS

Pharmacologic stimulants have been used to temporarily mitigate the effects of sleep deprivation and are used to increase the effectiveness of napping. However, prolonged use may have unpleasant and sometimes detrimental side effects. The effect of pharmacologic stimulants is more extensively covered in a previous thesis of the USMA longitudinal sleep study (Kenney and Neverosky, 2004).

AC. FORCED REST, NAP ENVIRONMENT AND SLEEP QUALITY

Studies agree that forced bed rest, the most controlled application of relaxation, is no substitute for sleep and does not provide the restorative or recuperative effects of even short sleep episodes (Curtis and Fogel, 1972; Lubin, et al., 1976). Comfortable chairs were not as effective as fully reclining beds when used as restorative napping environments as determined from subjective or objective data. From two studies on environmental effects on nap infrastructure and subsequent wakefulness, Dinges determined that naps taken in beds were more conductive to deeper sleep and greater post-nap subjective benefits. In addition, studies suggest that nap infrastructure is affected by environmental factors in much the same manner as is nocturnal sleep. Alerting environments such as ambient light and waking noises result in significantly less SWS and an increase in stage 1 sleep for one- or two-hour naps (Dinges, 1989; Dinges, et al., 1981).

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III. METHODS

A. PARTICIPANTS

The participants for this study were volunteers from the Cadet Class of 2007, United States Military Academy, West Point, New York. The pre-Cadet Basic Training survey was completed by 1,289 Cadets (Kenney and Neveroski, 2004). Mean age of the class at the start of the study was 18.7 years, with a range of five years and a standard deviation of approximately 11 months. Based on extensive medical examinations, Cadets were judged to be in excellent health. Based on athletic evaluation and training, they were considered to be good athletes. The profile for the Class of 2007 (Figure 13) is taken from the USMA web page.

USMA Class Profile for Year Group 2007

Volume of Applicants	Men	Women
Applicant Files Started.......	10,009	2,679
Nominated.....................	3,743	696
Qualified..................... (academically and in physical aptitude)	2,101	376
Admitted......................	1,120	194

Rank in High School Class	
First Fifth......	76%
Second Fifth.....	18%
Third Fifth......	5%
Fourth Fifth.....	1%
Bottom Fifth.....	0%

American College Testing (ACT) Assessment Program Scores*

Range	Eng	Math	Sci Reas	Read
31-36...	25%	28%	18%	45%
26-30...	54%	56%	52%	42%
21-25...	21%	16%	29%	12%
16-20...	0%	0%	1%	1%
11-15...	0%	0%	0%	0%
Mean....	28	29	28	30

College Board Scholastic Assessment Test (SAT) Scores*

Range	Verbal	Math
700-800.....	18%	25%
600-699.....	51%	57%
500-599.....	29%	18%
400-499.....	2%	0%
300-399.....	0%	0%
Mean.......	630	652

*Includes only scores used as a basis for admission.

Academic Honors

Class Valedictorians........................... 100
Class Salutatorians............................ 59
National Merit Scholarship Recognition.......... 192
National Honor Society......................... 824
Activities
Boys/Girls State Delegate...................... 232
Class President or Student Body President....... 234
School Publication Staff
 School Paper Editor, Co-Editor of Staff....... 161
 Yearbook Editor or Co-Editor.................. 117
Debating....................................... 165
Dramatics...................................... 171
Scouting Participants.......................... 550
 Eagle Scout (men) or Gold Award (women)....... 194
Varsity Athletics............................. 1197
 Letter Winner................................ 1155
 Team Captain.................................. 792

On 30 June, 1,314 new Cadets entered with the class of 2007 (1,302 United States citizens and 12 international Cadets), which includes 194 women, 64 African American, and 100 Hispanic candidates. The entering class includes Cadets from all fifty states. The 12 international Cadets were from 11 countries: Benin, South Korea, Ecuador, Kazakhstan, Costa Rica, Egypt, Philippines, Kuwait, Kyrgyzstan (2), Tunisia and Taiwan.

Figure 13. The Academic, Social and Athletic Profile of the 2007 USMA Cadet Class (From: http://www.usma.edu/Class/2007/profile.asp, accessed 05 October 2003).

At this phase of the study, all students were enrolled in the same basic curriculum with the same mandatory hours for academic study and physical training. Differences in athletic requirements were found between intercollegiate athletics, which require travel and its associated stressors, and intramural athletics, which do not require travel. Acceptance requirements for motivation, aptitude and academic achievement are extremely high. Cadet schedule differs from the average college schedule as well. Most colleges and universities allow students great flexibility in selecting, scheduling and determining class load. This is not so at USMA. All Cadets follow the same basic class schedule. All Cadets follow the same curriculum for their freshman and sophomore years (Figure 14). Classes may vary

for Second and First Class Cadets (juniors and seniors, respectively) who are busy pursuing the curriculum of their particular major. The schedule however, remains the same.

Fourth Class	**Modeling**	**Chem**	**Psych**	**History**	**Comp**	
	Calculus I	**Chem**	**IT1**	**History**	**Lit**	
Third Class	**Calculus II**	**Physics**	**Philosophy**	**Pol Sci**	**For Lang**	
	Prob/Stats	**Physics**	**Phys Geog**	**Econ**	**For Lang**	**Elective for Major**

Figure 14. Fourth Class = cadet freshman year, Third Class = sophomore year. Participants for this period of data collection were Third Class Cadets or sophomores (From: http://www.dean.usma.edu/Curriculum/CurriculumBriefing_files/frame.htm, Accessed 20 September 2006).

TYPICAL DAILY SCHEDULE	
Morning:	
6:55-7:30	*Breakfast*
7:35-11:45	*Class or Study*
Afternoon:	
12:05-12:40	*Lunch*
12:45-1:40	*Commandant or Dean Time*
1:50-3:50	*Class or Study*
4:10-5:45	*Intramural, club or intercollegiate athletics; parades; extracurricular activities; or free time*
Evening:	
6:30-7:15	*Supper (optional except Thursday)*
7:15-7:30	*Cadet Duties*
7:30-8:30	*Study Conditions/Extracurricular activities*
8:30-11:30	*Study time*
11:30	*Taps*
12:00	*Lights Out*
SATURDAYS*	
0735-0830	*Period 1*
0840-0935	*Period 2*
0945-1040	*Period 3*
1050-1145	*Period 4*
***EXCEPTION:**	**On home football Saturdays, Periods 3 and 4 are cancelled.**

Figure 15. Example of Cadet Daily Schedule (From: http://www.dean.usma.edu/sebpublic/usmacalendars/default.cfm?usr_actn=class_sched, Accessed 20 September 2006).

Class schedules leave little discretionary time (Figure 15). Breakfast and lunch on weekdays are mandatory. On Thursday, the evening meal is also mandatory. Weekend schedules vary. On some weekends, Cadets are free after their last class on Friday. Other weekends alternate Commandant Saturday or Dean Saturday. On these Saturdays, breakfasts are mandatory. Dean Saturdays are dedicated to academic activities such as examinations, lectures, films, seminars, makeup classes, etc. Commandant Saturdays are devoted to military program requirements. Physical Education classes cannot overlap with classes shown in Figure 15. The only flexible time allotted USMA Cadets is from the completion of their last scheduled event on Saturday to 0100 on Sunday and from 0520 to 1900 on Sunday. For these reasons, the Class of 2007 cannot be considered a sample of the U.S. college population in general.

Participants varied slightly for different portions of data collection throughout the study as participants were lost through attrition. A sleep survey, which included the Pittsburgh Sleep Quality Index (PSQI), was administered to 1289 of the 1,314 members of the class of 2007 at the beginning of Cadet Basic Training (CBT). The survey was intended to determine sleep patterns prior to arrival at USMA. Eighty Cadets, representing a stratified sample of gender, unit, and athletic (intramural and intercollegiate) status were selected to participate in Pre- and Post-CBT data collection. Mean age for this portion of the study was 19.25 years with a standard deviation of approximately one year.

B. PROCEDURE

1. Definition of Variables

For the purposes of this study, a nap was defined as sleep of 15 minutes to six hours in duration occurring after and non-contiguous to the Primary Nocturnal Sleep (PNS) episode. Sleep episodes which were nearly contiguous with the PNS episode were counted as part of PNS. Post-PNS occurrences of 15 minutes or greater which repeat over a period of three days were assessed as ultra-short sleep schedule, or the emergence of a sleep disorder. In certain instances, it was difficult to define a universal PNS episode for some Cadets participating in the study. Therefore, we defined a generalized PNS as continuous sleep which occurred between 2200h and 0500h and is virtually continuous. Breaks in sleep during this period were considered fragmented nocturnal sleep.

Only periods of sleep from 0500h to 2200h were analyzed except where naps clearly replaced nocturnal sleep episodes as was the case for some Cadets who practiced short or ultra-short sleep techniques. Due to the limitations of the actigraphic processing and the lack of agreement between actigraphy data and the self-reported log data, the interaction of sleep quality and total sleep time of individual naps and nocturnal sleep was left for future study.

2. Data Collection

Data collection plan for the longitudinal study included nine collection periods: one collection period during CBT (lasting for approximately 40 days), and one each academic semester (each lasting for approximately 30 days). For this phase of the four-year longitudinal study,

62 of the original 80 Cadets from the stratified sample submitted sleep logs for the period of 5 October 2004 though 5 November 2004. Actigraphy data were also collected during the same time period. Visual comparison of the actigraph with the sleep logs showed some discrepancies. Actigraphy data indicated little to no activity during some periods when the Cadets did not report sleep of any kind. Discrepancies can be explained in many ways: Cadets remove the activity monitors, but do not always report it; lecture periods can yield low actigraphy readings; fitful sleep can yield similar actigraphy recordings as those recorded during a lecture period. Sleep logs were considered more reliable in the event of discrepancies.

Sleep periods lasting between 15 minutes to six hours were attributed to napping with the following stipulations: sleep periods could not be contiguous with the PNS episode; sleep data could not be interpreted as a deviation to a CW or a SW schedule; sleep episodes in excess of three and one-half hours must show a previous nocturnal sleep episode within the 24-hour period. The sleep logs collected data in 15-minute increments. Sleep episodes of less than 20 minutes in duration were collected but were evaluated separately as time during which no napping benefits were gained. Sleep episodes between the hours of 0500h and 2200h were input to the database, with consideration of the timing of the PNS episode.

3. Assumptions

The following assumptions were made during data processing and analysis. Sleep log data are accurate enough to provide insight into patterns of behavior. Since sleep logs were used in this study, only assumptions based upon

the scientific literature can be made with respect to the depth and quality of the sleep in question. According to the scientific literature, naps less than 15 minutes in duration are not beneficial for improvement in mood, cognitive task performance or reaction time. Morning naps contain primarily REM, stage 1 and 2-phase sleep and as such, have lower sleep inertia and may be more beneficial for memory consolidation. Naps taken in the afternoon are primarily composed of SWS and deeper sleep stages 3 and 4. They are more likely to be accompanied by greater sleep inertia but are more likely to improve mood and performance. Longer afternoon and evening sleep episodes are more likely to contain increasing levels of REM once SWS quotas are met. Research has not yet identified a baseline requirement for SWS. The body seems to demand SWS proportionately with increasing sleep debt and will eliminate other phases of sleep in order to obtain it. Longer periods of sleep will improve performance for greater periods of time following the nap. Improvement in performance will continue to increase up until approximately two hours after the nap has concluded.

C. APPARATUS

1. Hardware

a. Actiwatch® and Actigraph® Wrist Activity Monitors (WAMS)

An Actiwatch® is an actigraphy-based data logger equipped with a sensitive accelerometer. The instrument is designed to wear on the wrist and records a digitally integrated measure of gross motor activity (Actiwatch, 2004; Kenney and Neverosky, 2004). (See Figure 16)

Figure 16. Actiwatch Actigraph® (From: http://www.minimitter.com/Products/Actiwatch/index.html).

b. Activity Logs

Paper logs were created for manual data entry by Cadets (Figure 17). The logs became the primary data source for analysis due to complications with the Actiware® software data, discussed later in this document.

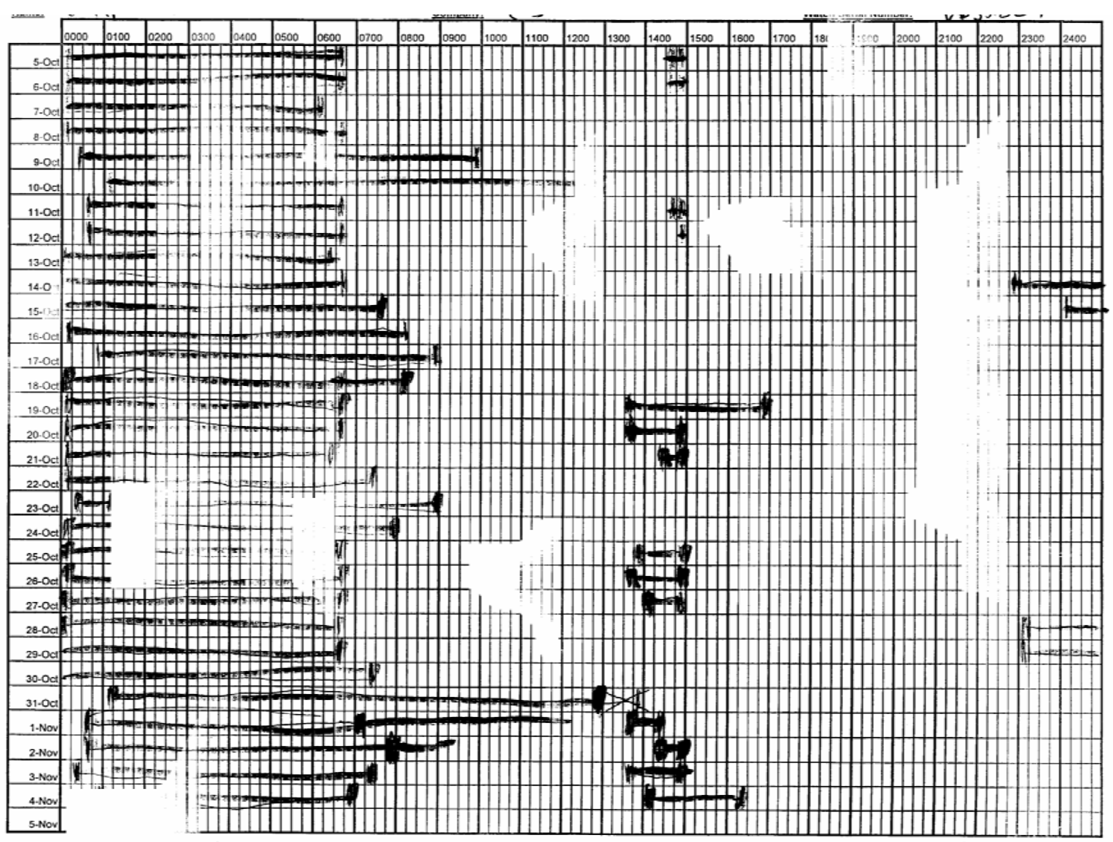

Figure 17. Sleep logs designed for and used by Cadets for capturing sleep and nap data for the fall of 2004.

2. Software

a. Tools

Actiware®, FAST™ and Excel® software programs were used for data collection, entry or analysis.

b. Versions of Software

The Actigraphy data was downloaded in November 2004 using Actiware® Version 3.4.1. The Actiware® Version 5.0, was specifically designed to resolve problems with nap analysis in earlier versions of the software but would not upload nap data downloaded using an earlier version of software. Therefore, it was not possible to analyze the data from this collection period using the Actiware® Version 5.0 Nap Analysis Module. Neither was it possible to determine the benefit this napping data had on fatigue avoidance and predicted performance through the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE™) software. Due to these software difficulties, some analysis was attempted using Actiware® Version 3.4.1.

c. Actiware® Nap Module and Nap Algorithm

It is not apparent if Actiware® software designers treat naps different from primary nocturnal sleep. The napping algorithm does not address changes in sleep architecture and content associated with nap times. These issues are critical to determining not only the value of the nap but also the value gained from specific kinds of sleep. Two important factors to any napping study are the amount of REM and the amount of SWS, which are regarded as affecting memory consolidation, mood, cognitive processing and reaction time in performance. It is essential that the software not only treat sleep from nocturnal sleep episodes and naps differently but also that the algorithm treats

naps of different duration and different times of day differently, due to their differing SWS and REM content. All naps are not identical. The Actiware® Version 3.4.1 records multiple bouts of wakefulness in a nap as separate sleep episodes (Figure 18). Naps in excess of three hours are not stored as naps, even if the sleep episode could not be considered part of the nocturnal sleep episode. For these reasons, nap episodes were not recorded by Version 3.4.1 in a manner useful to this particular study.

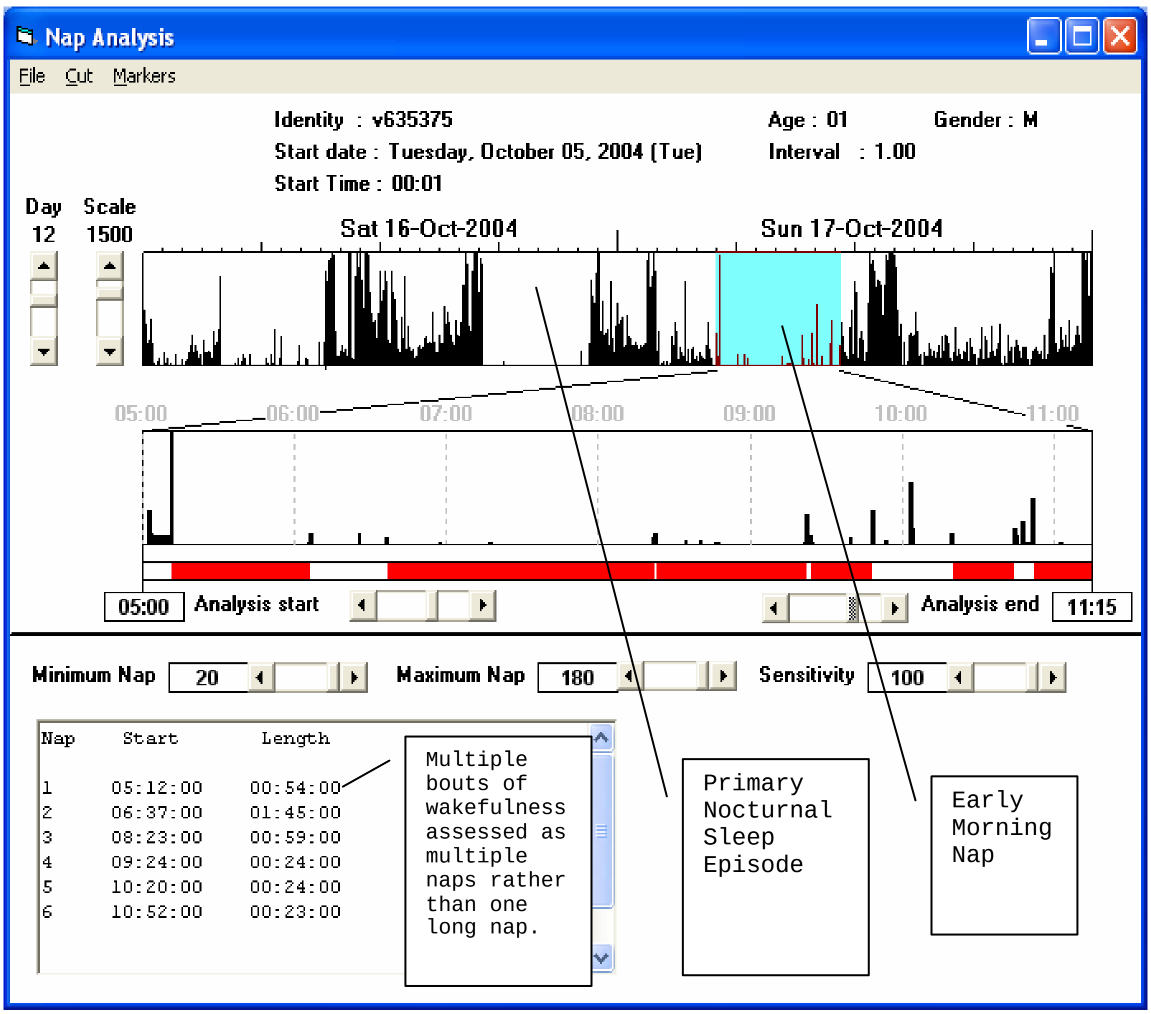

Figure 18. Illustration of Actiware® Version 3.4.1. Nap Module treatment of sleep episodes.

d. Nap Length

Each individual napping episode was manually scored, cut and pasted into a document, then input into a spreadsheet. Where necessary, bouts of wakefulness during a nap were extracted from the data and total nap time was calculated when the software interpreted multiple naps with bouts of wakefulness. Actiware® limits nap length to 180 minutes or three hours. Some naps taken by Cadets reached durations of six hours and could not be counted as nocturnal sleep as it was non-contiguous with nocturnal sleep, and was not patterned after a CW or SW profile. Seventeen naps, 4.5% of naps reported during this period, were in excess of three hours. More importantly, naps in excess of three hours comprised 13.7% of the total sleep time gained by napping; naps of this duration are likely to contain REM and SWS regardless of time of day.

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IV. RESULTS

A. DISCUSSION

As in many field studies, there are uncontrolled influences in this data set. Some of the data influencing fatigue, sleep and napping which are not captured and would be of use in creating a robust model are: nap and nocturnal sleep efficiencies, nap and sleep environmental factors, sleep phases, stress, pre- and post- nap effects, individual tendency toward napping prior to the study, time free environment behavior (where students are able to set their own schedule) and, perhaps most importantly, daily performance data. To date, a model, which projects that a nap at a certain time of day of a certain length yields an improvement to performance such as increased vigilance, does not exist.

The answer to questions like, “Does nocturnal sleep affect duration of naps?” is quite well known. The answer to: “How much sleep does the human body require before it becomes militarily ineffective?” and “How much sleep does the human body need before life ceases?” can all be found in existing literature. What we would like to be able to say is something like: “We are 95% confident that a 20-minute nap, taken between 1000h and 1200h for three days in a row, just prior to a math test, yields a .5 increase in test score with a SD of .2.” Unfortunately, we simply do not have the sort of data that would support that kind of definitive statement in this field environment. To say for instance, that “Cadets who napped got significantly higher scores on PT tests than Cadets who didn’t nap” is also beyond the scope of the current effort.

Unfortunately, the SAFTE model does not address variables known to have an effect on napping, e.g., caffeine, soft-drinks and tobacco products. It is not possible to determine if changes in use of such stimulants have an effect on total sleep time, total nocturnal sleep, nap frequency or nap placement in the 24-hour day.

Traditional sleep analysis (e.g., analysis of nocturnal sleep start time), although pertinent to primary nocturnal sleep, lacks relevance to the current study and does not provide useful information when applied to napping. The duration and timing of naps is known to be important when assessing the value of naps. From scientific literature describing sleep studies in isolation, we know that PNS affects time of day, length of naps and frequency of naps. Cadets substantiate the scientific literature: in the college environment, and specifically in the USMA Cadet environment, academic demands and schedules have more to do with the timing and duration of naps than does the length of PNS. Such nap scheduling, if applied in conjunction with similar research based nocturnal sleep routine, should yield measurable improvements in reaction time, cognitive reasoning, mood and physical performance.

B. NAPS TAKEN OVER THE COLLECTION PERIOD

A total of 62 Cadets reported data over a 32-day period for this phase of the four-year study. A total of 607 naps were taken for a total of 45,018 minutes or 75.3 hours of sleep. Naps ranged from 15 minutes to six hours (360 min) in duration.

C. NAPS TAKEN OVER THE DAYS OF THE WEEK

In each work week, the fewest naps occurred on weekends. Weekend naps are boxed in red in Figure 19. Just

as the number of naps per day appears sinusoidal (Figure 19), start times within the day tend to appear sinusoidal as well (Figure 20).

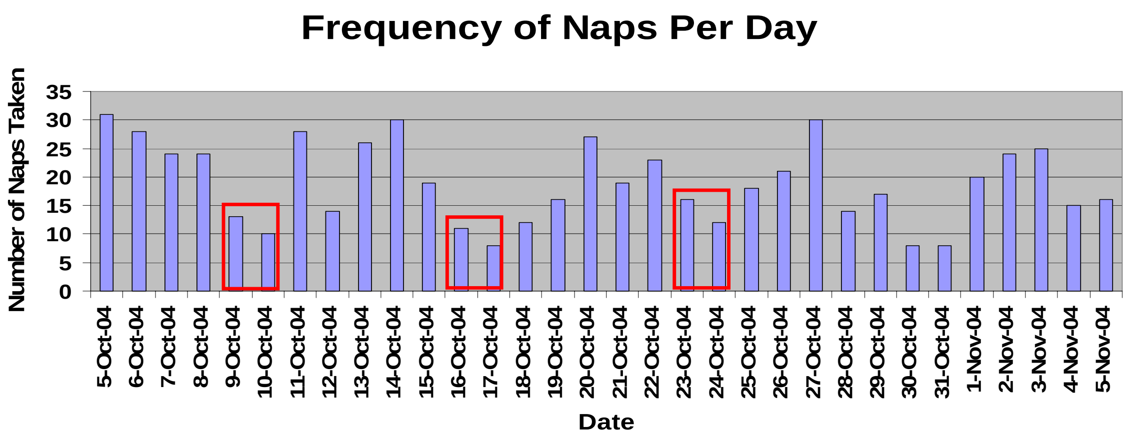

Figure 19. 607 Self-reported nap episodes of USMA Cadets (n=62) distributed over 32 days from 4 October to 4 November 2004. Weekend nap incidents are boxed in red.

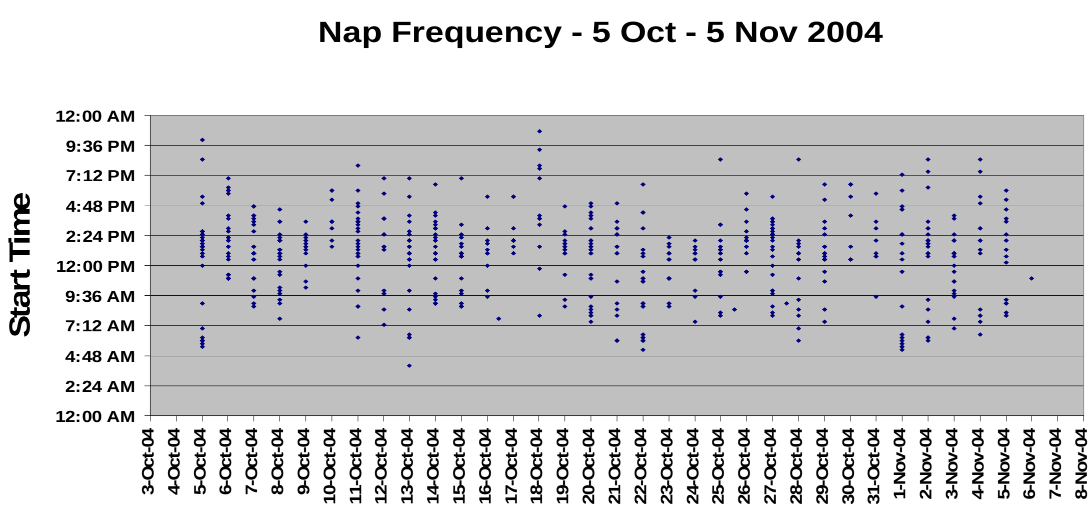

Figure 20. Scatter plot of nap incidents over 32 days.

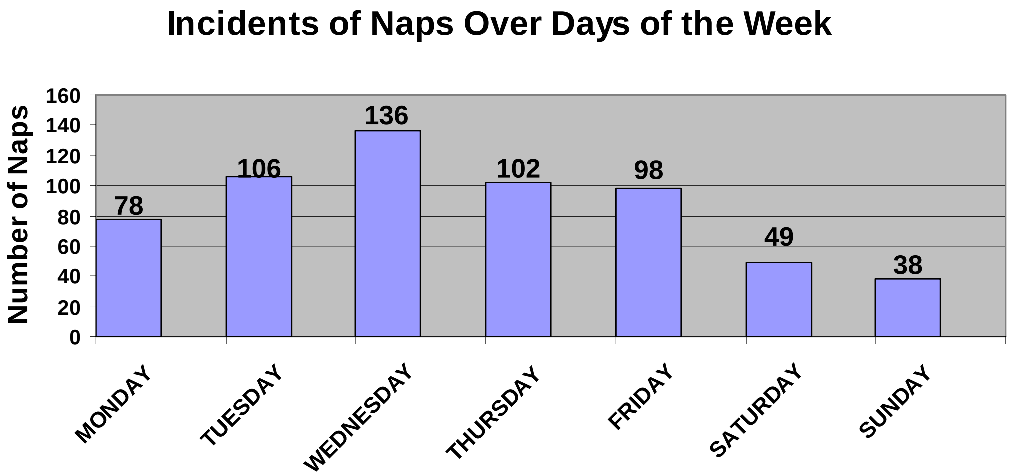

Figure 21. Number of nap incidents aggregated by day of the week.

The greatest number of incidents and frequency of naps was on Wednesdays, followed by Tuesday, Thursday and Friday, with Saturday and Sunday nap occurrences trailing behind all other days of the week (Figures 21 and 22). In terms of percentages, 22% of all napping done during the week occurred on Wednesdays. Tuesday and Thursday each accounted for 17%, with Friday accounting for 16%. These four days, account for approximately 72% of nap incidents over a week.

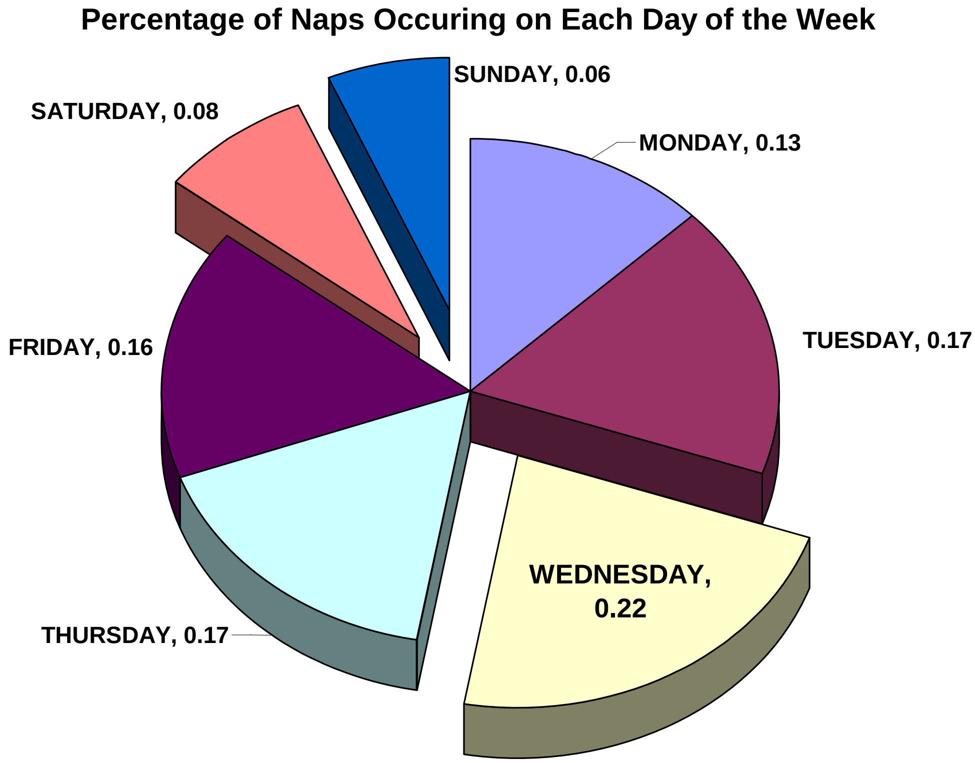

Figure 22. Relative frequency of naps taken stratified by day of the week N=62, total nap observations = 607 over 32 days.

Not only were incidents of napping more frequent on Wednesdays but the total sleep time gained from Wednesday napping was also greater than on any other day of the week. The length of naps on Wednesdays (Figure 23) averaged 2.7 hours (2 hrs and 41 min). What is noteworthy is that more naps were taken in the middle of the academic week than were taken on weekend days when schedules would presumably be more flexible allowing more students to nap more frequently and longer. This finding is the first indication that naps on Friday may have been recuperative in nature. On Fridays, Cadet work/schedule requirements, which drive prophylactic napping, decreased. Sleep log

entries indicated that sleep deprivation accumulated over the week. According to scientific literature, sleep deprivation typically forces recuperative napping.

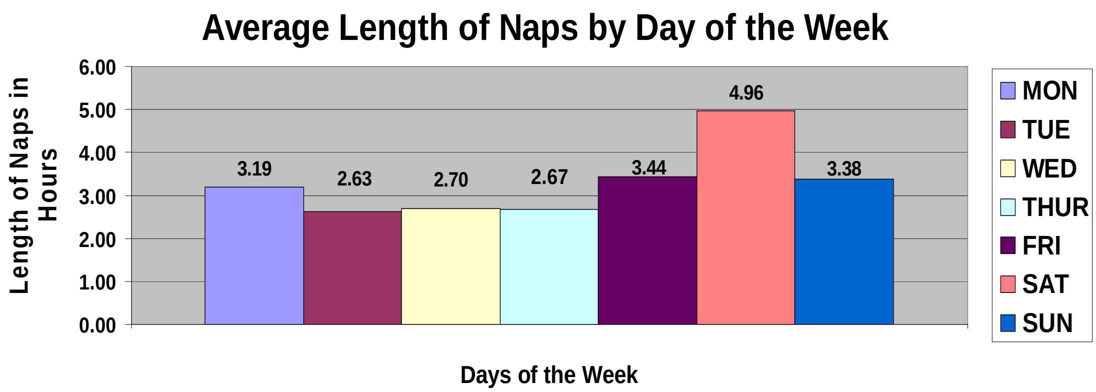

Figure 23. Average length of naps per day of the week.

D. WEEKDAY VS. WEEKEND NAPS

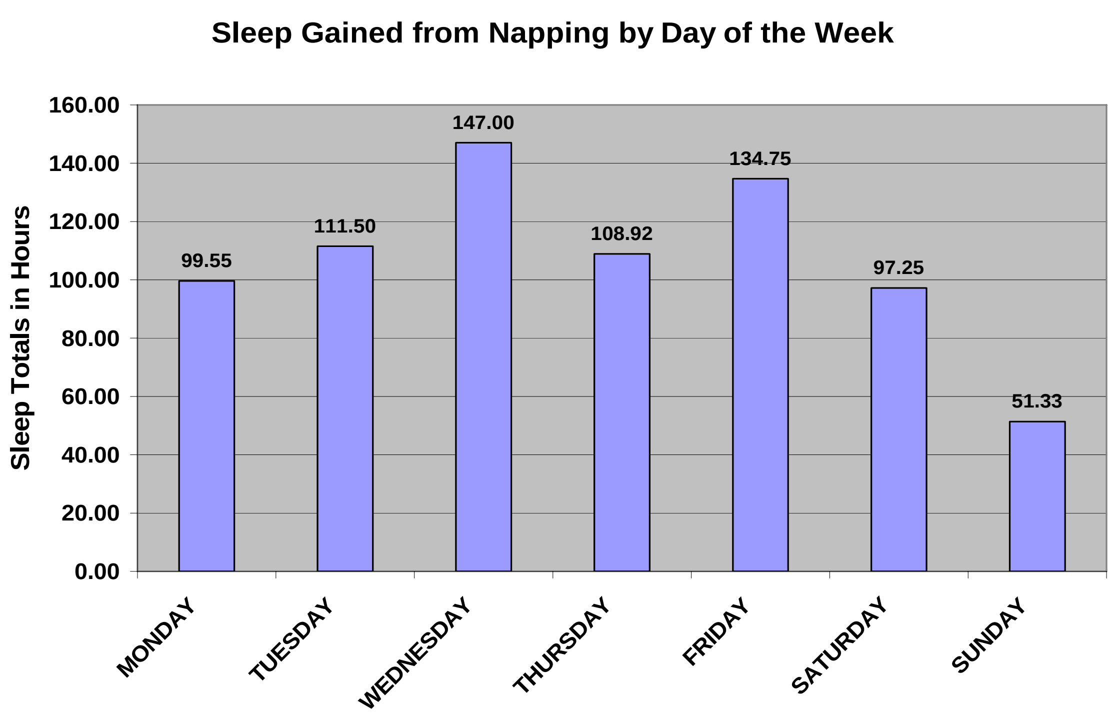

Figure 24. Total hours of sleep gained from napping alone over the period of 32 days, stratified by day of the week.

Weekend naps contributed the least amount to TST over the week in addition to occurring less frequently (Figure 24). One might expect cadets to get fewer but longer naps on the weekends. However, Cadets did not use the large blocks of time available on weekends for napping.

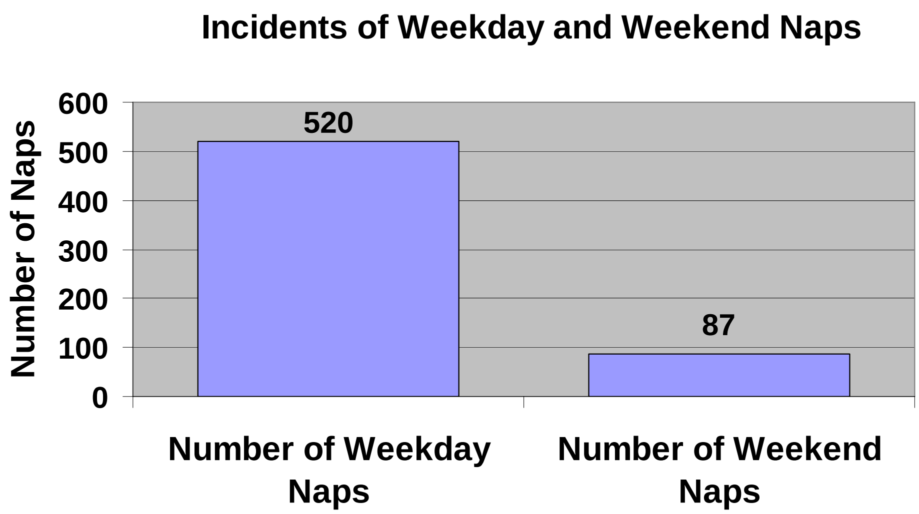

Figure 25. Weekdays and weekend nap incident totals.

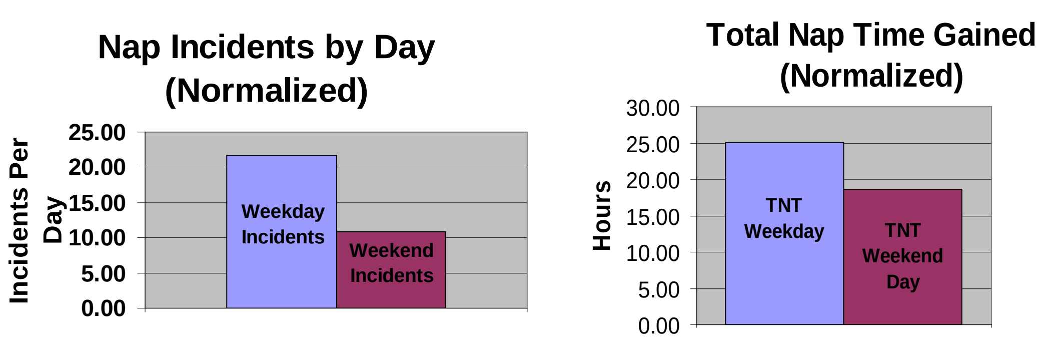

Figure 26. Average weekday vs. average weekend naps (incidents and lengths).

On average, a total of 22 naps were taken for any given weekday for an average of 25 hours of TNT. An average of eleven naps were taken on any given weekend day

for an average of 22 hours of TNT. In general, fewer and longer naps were taken on the weekends (Figures 25, 26, 27).

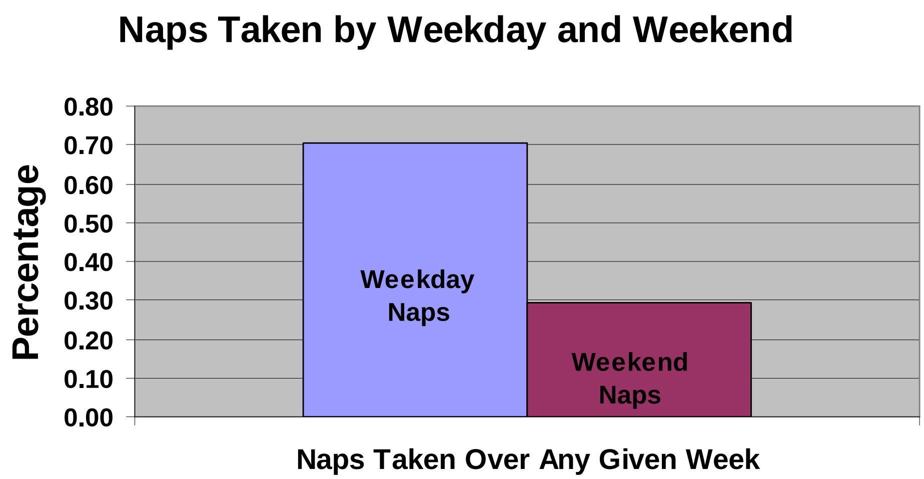

Figure 27. Weekday and weekend naps (normalized by day).

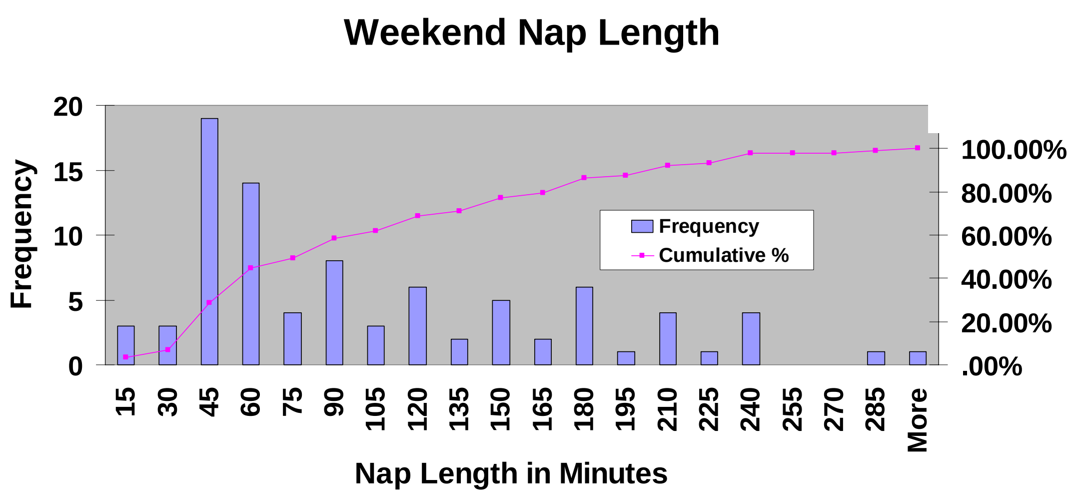

Figure 28. Weekend nap length.

There were 520 incidents of weekday naps (Figure 25) representing 86% of naps taken and 80% of the TST gained from napping (Figure 29). Cadets received 87 weekend naps

(Figure 25), representing 14% of naps taken (Figure 29) and 20% of the TST gained from napping (Figure 29) over a week-long period.

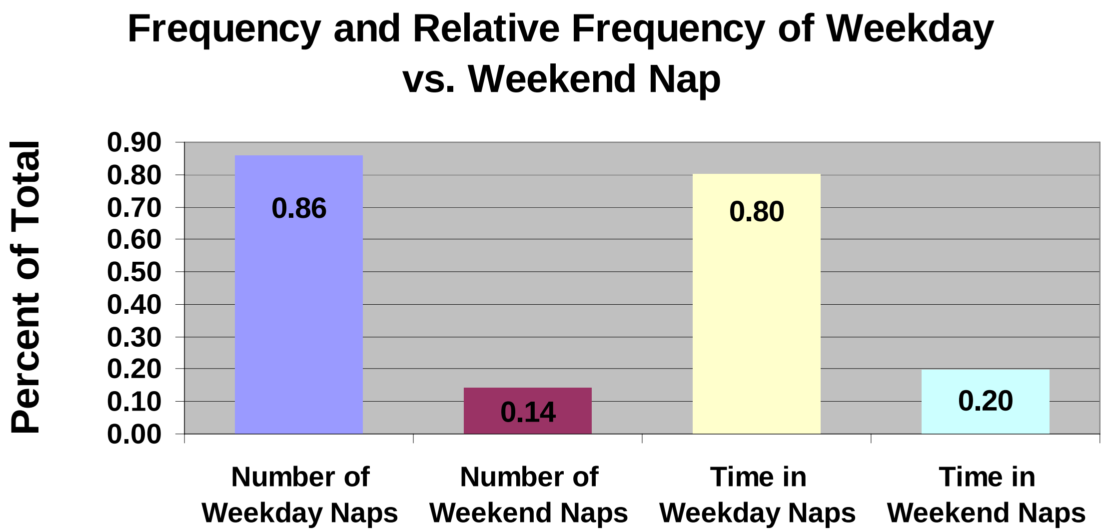

Figure 29. Percentages of incidents and total sleep time gained from napping stratified into weekend and weekday.

E. TOTAL NAPS BY TIME OF DAY: MORNING, AFTERNOON, EVENING

By far the majority of naps taken by Cadets are afternoon naps (Figure 30) when greater slow wave sleep and greater sleep inertia is likely. This could represent available time in their schedules rather than a predisposition or need to nap in the afternoon vs. morning. Regardless, the data suggest Cadets are gaining greater amounts of deeper stages of sleep as opposed to Stages 1 and 2 with associated REM. However, if memory consolidation occurs with REM as scientific literature indicates, Cadets may be missing the memory consolidation effects, which occur with REM. They are missing sleep when REM is most likely to occur: sometime after seven hours

continuous primary sleep episode, during morning naps and at the end of naps which exceed three hours in duration (depending on degree of sleep deprivation).

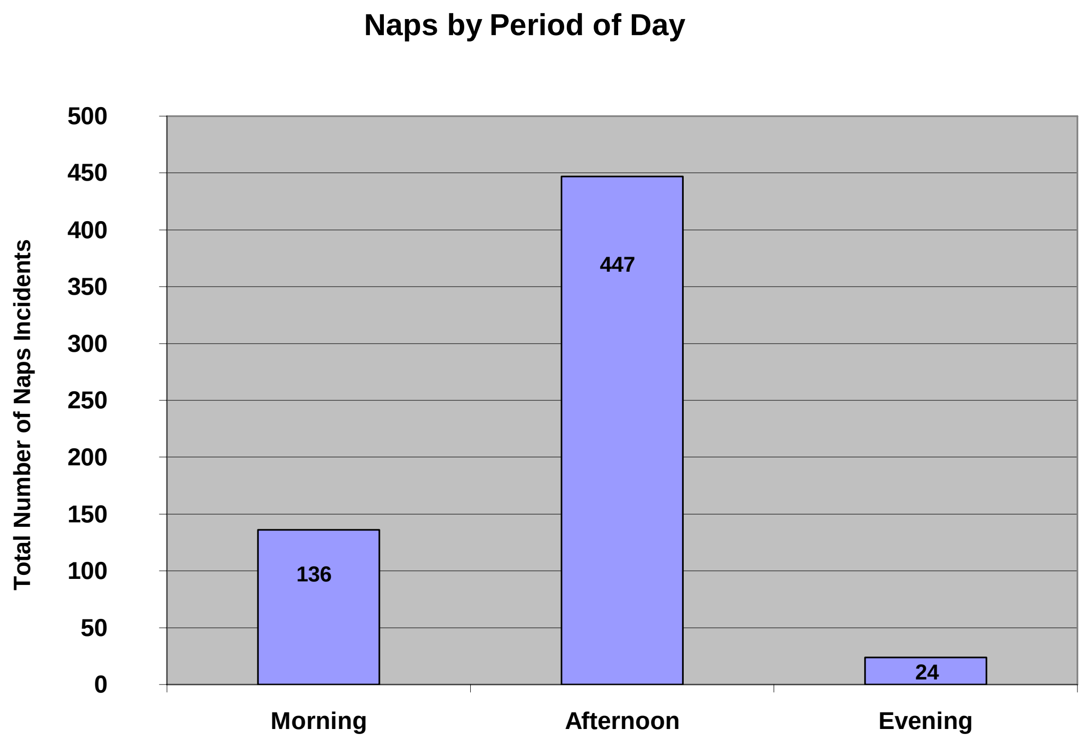

Figure 30. Totals of nap incidents stratified by time of day.

F. TYPES OF NAPS TAKEN AS DETERMINED BY LENGTH OF NAP (AVERAGE BY DAY, AVERAGE BY WEEKDAY VS. WEEKEND AND TOTAL)

The data indicate that nap duration is well managed. That is, the majority of naps last between 20 minutes and two hours (Figure 31). These nap durations provide a good balance between the benefits and detriments, which naps offer: minimizing sleep inertia while maximizing performance enhancement. The number of comparatively long nap times does indicate that a biological demand for greater amounts of sleep was present throughout the data collection period.

Naps were stratified by duration of sleep period and corresponding to changes in sleep infrastructure. For instance, as previously stated, scientific literature suggests a predominance of SWS and increased amounts of sleep stages 3 and 4 with increasing sleep length, debt or afternoon nap times. However, confirmation of this supposition would require polysomnographic data, beyond the scope of the current effort.

Naps of less than 20 minutes, as stated previously, were assessed as being without value for performance enhancement in this analysis. Research indicates that naps of 20 minutes to one hour provide an improvement in performance with little sleep inertia while naps in excess of one hour result in increasingly large amounts of sleep inertia. At two to three hours, sleep inertia cannot be ruled out and it may take up to 30 minutes to recover before performance can be normalized. For these two- to three-hour long naps in the afternoon, REM sleep may begin to emerge in most subjects. For afternoon naps of three hours duration, REM is likely to occur in addition to SWS. For data analysis purposes, the naps over the collection period are stratified accordingly.

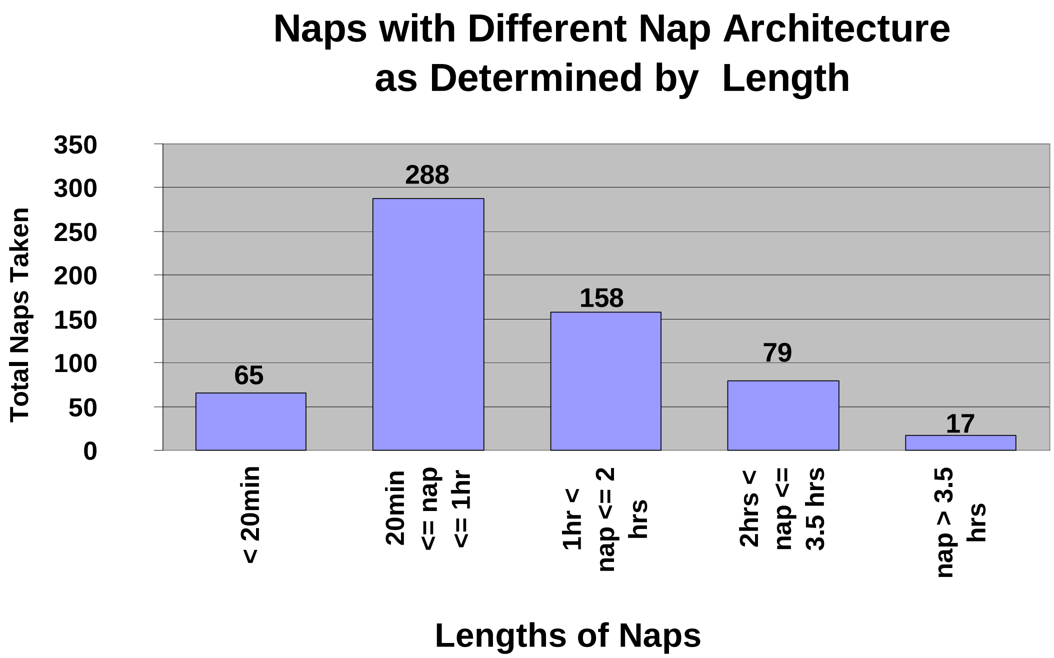

Figure 31. Total nap incidents, stratified by duration.

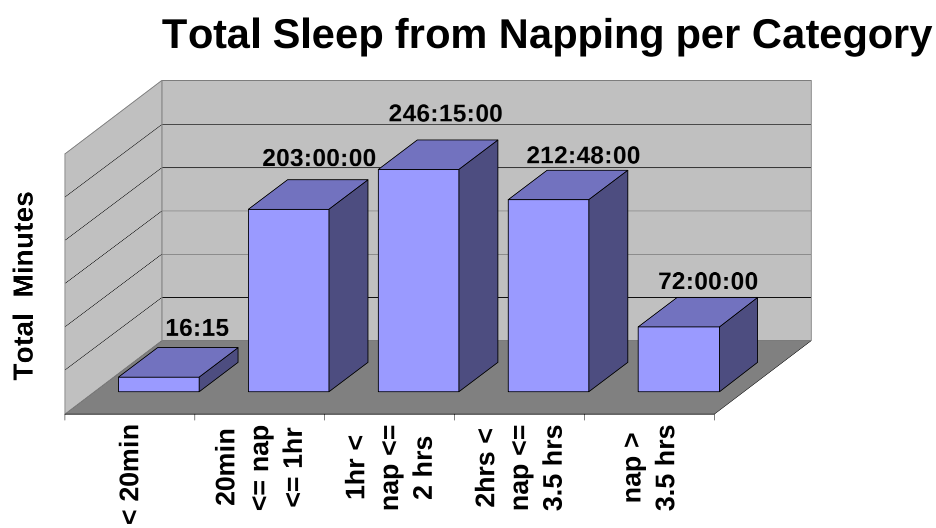

Figure 32. Total hours of sleep acquired from napping, binned by sleep architecture.

Approximately 50% of all naps taken were 30 minutes to an hour in duration representing a healthy nap duration

practice (Figure 34). Nearly 79% of all naps taken were less than one hour and fifteen minutes in duration (Figure 34).

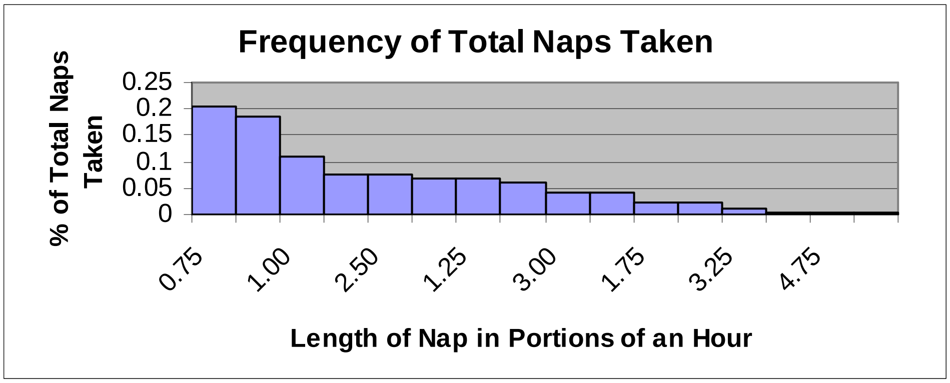

Figure 33. Relative frequency of naps, by duration.

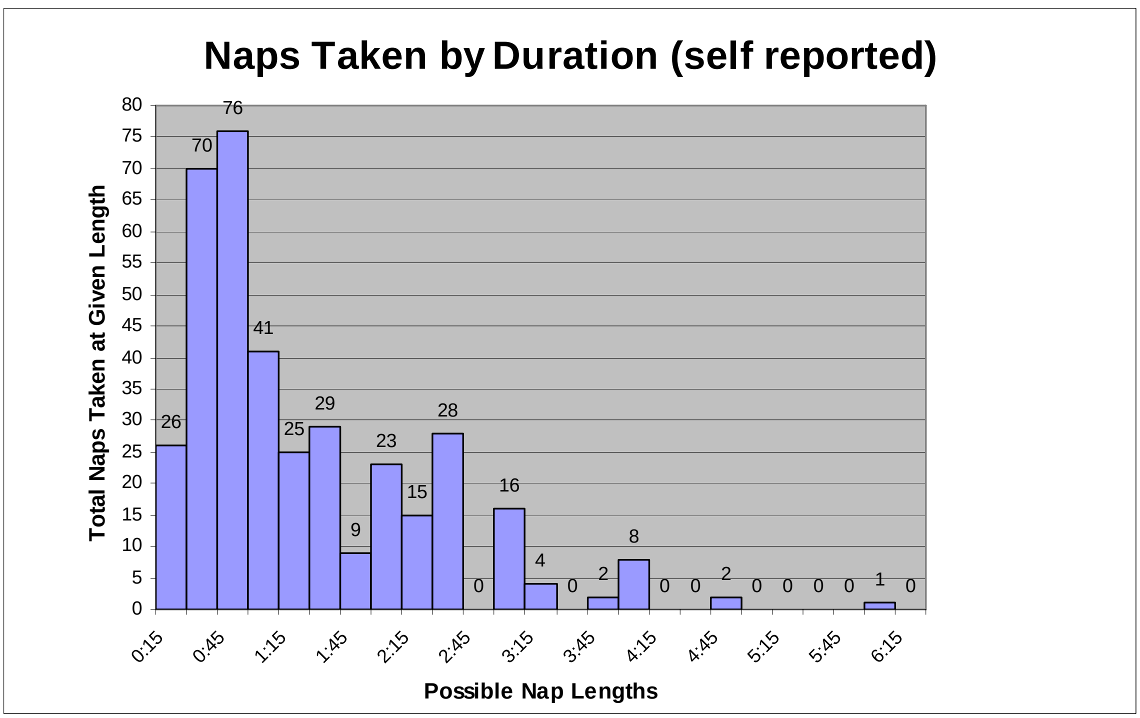

Figure 34. Total naps taken stratified into 15-minute increment durations.

G. TYPES OF NAPS TAKEN OVER ALL DAYS, ALL SUBJECTS

Data collected during this time period indicates that Cadets were not capable of overindulging in napping. Of the

three types of naps, appetitive, prophylactic and restorative, Cadets were only probably only capable of obtaining restorative naps. Daily nocturnal sleep totals indicate that Cadets never sustain nocturnal sleep totals of nine to ten hours (optimal) or even seven hours (acceptable), forcing a steady state of sleep deprivation over the entire period, even after weekends of unrestricted sleep. This indicates that naps, (even if Cadets intended to take prophylactic naps), become restorative. No Cadet, even an appetitive or prophylactic napper, reached sufficient stores of nocturnal sleep to commence appetitive or prophylactic napping behavior. Data indicate Cadets were napping to correct a baseline deficiency (restorative napping), rather than storing up sleep (prophylactic napping) or for the pleasure of it (appetitive napping).

V. RECOMMENDATIONS AND CONCLUSIONS

A. RECOMMENDATIONS FOR FUTURE RESEARCH

1. Survey - Habitual and Non-Habitual Napper Determination

Future surveys could determine if Cadets are habitual, non-habitual or non-nappers prior to CBT. This information may yet be obtainable for the class of 2007. Cadets may be able to recall pre-CBT napping behavior and such data may prove valuable in determining an individual’s capability to nap effectively and efficiently.

A further exploration could determine if morningness and eveningness preference is correlated with nap times, durations and frequencies of habitual and non-habitual nappers. Morningness and eveningness preference are diurnal types which have been used in scientific literature since the 1930’s. These sleep and activity patterns are also referred to as “Lark” and “Owl.” They define the tendency to rise early or late and perform well early or late in the 24-hour cycle. Core body temperature peaks and nadirs are one of many biological functions linked to these types lending validity to the argument that they are biologically rather than environmentally determined (Carskadon, Rechtschaffen, Richardson, Roth, Siegel, and Herman, 1993).

2. Actigraphy Data

A new and more reliable source of actigraphy data that allows analysis of napping and is compatible with FAST™ should be developed for data collection.

3. Sleep Logs

Activity logs are helpful in examining sleep patterns and a version has been prepared for use with Personal Digital Assistants (PDAs). Care should be taken that the

hour of 2400h to 0100h is not counted twice on the logs. If an individual changes current napping strategy and/or there are changes to napping policies, these events could be monitored and recorded using logs and surveys. If specific nap schedules are centrally implemented for participants, logs could be filled out ahead of time as part of the Cadet’s schedule and checked off as the plan is followed, reducing administrative burden for the participants. Simple, short, web- based surveys of mood, perceived alertness, and memory could be developed as part of a daily log-in.

4. Objective Sleep Quality and Sleep Efficiency Data in a Lab Environment

Serious consideration should be given to adding laboratory test data such as reaction time tests, cognitive testing and electroencephalography to future efforts to assess sleep and napping. These tests can provide quantitative data on sleep stage (giving insight to memory consolidation), type and value of napping experienced (restorative or prophylactic), length of sleep latency and their effects on reaction time, mood, and cognition. From such data, it may be possible to develop an effective predictive model of Cadet napping needs and performance. At the very least, such data collection could be restricted to weekends when Cadets might be more likely to have the time for such data collection actives. Weekends are also suggested because this is an area where the 2007 Cadet napping profile shows the greatest departure from students of the same (adolescent) circadian rhythm. Weekends are the time when this sample shows it benefits least from napping.

B. RECOMMENDATIONS FOR NAP TECHNIQUES

1. Prophylactic Naps

Use of prophylactic naps, which would most likely be possible on weekends, could potentially result in improved performance in mood, cognitive skill, vigilance, endurance and athletic tasks, particularly in the early days of the week.

2. Length of Naps

In general, naps of less than 15 minutes should be increased to 20 minutes or more. Research indicates that ultra-short naps of five minutes or less only provide benefit in instances of total sleep deprivation, whereas naps of 20 minutes or more are associated with improvements in mood as well as cognitive, vigilance and speed task performance. These effects have been shown to increase with the duration of the nap.

3. Nap Protocol Followed Over Extended Periods of Time

All nap schedules should be continued over three or more consecutive days, in order to see performance improvements. This schedule was rarely seen in data from this study.

4. Sleep Inertia

Post-nap performance improvements may continue to increase for up to three hours after the nap particularly if the nap exceeded one hour in duration. Naps lasting one hour or more may result in worse than pre-nap performance levels for up to 30 minutes immediately following the nap. Cadets should plan accordingly. Sleep inertia can be lessened if naps are taken in the morning and do not exceed one hour at any one time. As sleep deprivation accumulates, afternoon naps of longer duration may be necessary. In such

cases, sleep inertia should be expected and can be lessened in magnitude through skillful application of non-abrupt alerting systems, light application, and water applied to the face.

5. Command Support

Cadets should be educated on the findings detailed in nap literature. With guidance, and support from the USMA command, cadre, faculty and administration, Cadets should organize and plan their nap schedules to address individual needs. If an individual’s memory seems less responsive than in high school days, the Cadet could try to get morning, as opposed to afternoon, naps if his or her schedule allows.

C. CONCLUSION

This thesis attempts to identify and provide a baseline for the napping behavior and daytime sleep requirements of the 2007 Cadet class and assess their value as determined through laboratory and field studies detailed in nap literature. This research could provide napping awareness, aid research-based systematic and consistent nap scheduling. This effort should be just the beginning for future research, which could provide measurable benefit for optimization of sleep/nap practices not only for this Cadet class and those following, but also for the future leaders of the Army. Intelligent and informed application of napping principles and techniques will contribute to improved performance and enhance the efficiency of the human military system.

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